INSTRUCTIONS

[redacted]

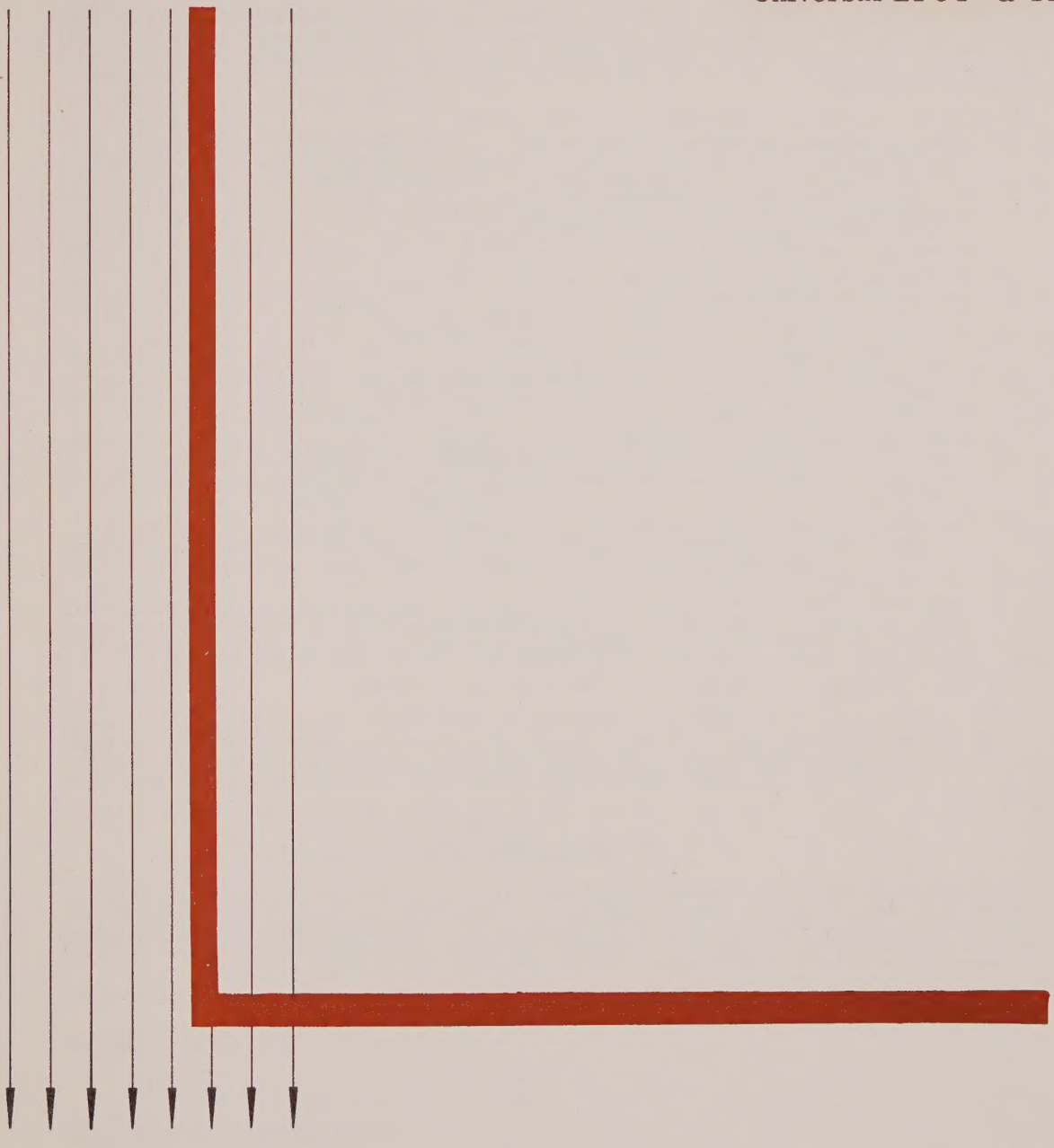
Beckman®

INSTRUMENTS, INC.
BERKELEY DIVISION

INSTRUCTION MANUAL

MODEL 6144

Universal EPUT® & Timer



Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

September 1963

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

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(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

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(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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MODIFICATIONS - 6100 Series

SCHEMATIC DIAGRAMS

Model 696 A415929-Rev. A

continued. . .

Unit Logic	63-D-41
Count Logic	D416156
2.5 Mc Amplifier	C416020
Control	C411898
Time Base Logic	C411897
"F" Logic	C412112
"B" Logic	C412443
"M" Logic	C411927
Power Supply	D411974
Recycle	D411909
Legend	C411783
1 Mc Oscillator and Shaper	C411996

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Instruction Manuals:

Model 850 Decimal Counting Unit

Model 860 Decimal Counting Unit

Data Storage Unit

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SECTION 1

INTRODUCTION

1.1 GENERAL

The solid-state Beckman Model 6144 is a multipurpose 2.5 mc counter and timer designed to measure frequency, period, time interval, and frequency ratio. This versatility is complemented by an easy-to-read electroluminescent display panel, which provides a seven digit reading, and displays the correct unit of measurement and the appropriate decimal point.

Special features incorporated in the Model 6144 extend the flexibility of the instrument and increase its usability. For example, the MULTIPLE PERIOD setting of the MODE selector allows the operator to time and average as many as 10^6 periods, thus increasing the accuracy of period measurement.

LATCH and FOLLOW positions of the POWER switch provide another feature. In LATCH, there is a continuous EL display during a count interval, but in FOLLOW the EL display is continuously updated in its presentation during a count interval.

A TEST feature enables the operator to check the instrument for proper operation. See paragraph 2.5.

1.2 SPECIFICATIONS

Specifications for the Model 6144 are given in Table 1-1.

Table 1-1

Input Frequency Range	
Frequency Measurement	dc to 2.5 megacycles
Interval Measurement	Period: 1.0 microsecond to 10^7 seconds with 1.0 microsecond resolution (dc to 1 mc)

	Multiple periods: 3.3 microseconds (dc to 300 kc)
Input Resistance	INPUT's X and Y: 1 megohm shunted by 40 pf. AC coupling uses a .02 μf, 600V capacitor in series.
Input Sensitivity	INPUT's X and Y: 0.1 volt rms (0.3 volt peak-to-peak)
Maximum Input Voltage	INPUT's X and Y: DC: ±50 volts dc on 1 ATTEN FACTOR, ±600 volts dc on 10 and 100 ATTEN FACTOR AC: 50 volts rms on 1 ATTEN FACTOR, 600 volts peak (dc + ac) on 10 and 100 ATTEN FACTOR
Input Attenuation	1, 10, 100
Trigger Voltage Range	±1 volt, ±10 volts, and ±100 volts on 1, 10, and 100 ATTEN FACTORS respectively.
Resolution Gating Counting	 Better than 0.4 microseconds Better than 0.4 microseconds
Oscillator Stability	3 parts in 10^7 per week with ±10% line variation and ±10 degrees C temperature variation

Accuracy Gating Period	 ±1 count ± time base crystal accuracy. Sine wave single period measurement accuracy is 0.3% at 1 volt rms input, and sine wave noise content 40 db down.
Multiple Period	±0.3% trigger error divided by periods averaged.
Time Base	1μsec. to 10 seconds in decade steps as selected by the TIME selector.
Recycle Rate	Continuously variable from 0.1 cps to 7 cps.
Visual Readout	Seven electroluminescent digits with automatically selected decimal points and unit nomenclature (KC, MC, μSEC, mSEC, and SEC).
Electrical Readout	Four-line 1-2-4-8 binary coded decimal Binary 0: -10 volts with respect to ground. Binary 1: Ground potential or slightly negative.
Operating Temperature Range	-20°C to +65°C
Storage Temperature	-55°C to +75°C
Power Requirements	117v ac, 50/60 cps, 100 watts
Dimensions	5-1/4" high, 16-3/4" wide, 19" deep
Weight	40 pounds

1.3 APPLICATIONS

Many laboratory, field test, and production line requirements are satisfied with the versatile Model 6144.

Laboratory uses might include frequency and stability checks on circuits under design, period measurements of low frequency waveforms where long term stability is essential, use as a secondary frequency standard, or calibrating less accurate frequency monitoring equipment.

The remote programming feature of this instrument makes it extremely useful for field test applications in integrated systems. An example would be in a military missile check-out system where a computer would remotely program the Model 6144 to measure period, frequency, ratio, etc., of the various electronic circuits in a missile guidance system.

Various transducers such as photocells, magnetic pickups and switches are useful in translating physical phenomena into voltage changes. With appropriate transducers, this instrument measures characteristics of such events relative to time. A few of the many applications are:

Frequency measurements	Tachometry
Frequency ratio measurements	Telemetry
Relay and switch timing	Pulse height analysis
Phase measurements	Oscilloscope time base calibration
Ballistic measurements	Secondary frequency standard

1.4 ACCESSORIES

The Model 1453 Printer, designed for use with this instrument, converts count information into a printed record on a standard adding machine tape. This printer is ideal for making long term stability checks, recording voltage changes, or making a permanent printed record in control or measuring systems.

Beckman Model 651 Voltage-to-Frequency Converter plug-in indirectly allows the Model 6144 to measure dc voltages from 0.1 volts to 1000 volts. Other plug-ins are being developed for use with this counter.

A Beckman Digital to Analog Converter converts the count accumulated during each counting period to a representative voltage level. This voltage level is retained until a new count is made, at which time the converter changes its voltage level to conform to the new count. The changing levels can control the operation being monitored, or when applied across a self-balancing potentiometer, drive a pen recorder for an analog record.

SECTION 2

OPERATION

2.1 GENERAL

The Model 6144 has two input circuits, a time base generator, a signal gate, a chain of decimal counting units, and Data Storage Units with an EL display. The input circuits (INPUT's X and Y) produce output pulses representative of the voltage change at their inputs. These pulses can be used as start, stop, or count signals. The time base generator produces clock pulses (selected by TIME selector) which also are used as start, stop or count signals. Depending on the mode (E/UT X, TIM X-Y, etc.) selected by the MODE selector, the three pulse sources supply start signals to open the gate, stop signals to close the gate, and count signals which pass through the gate to be counted by the DCU's. The count accumulated by the DCU's is transferred to the Data Storage Units (DSU's), and then displayed on the EL panel.

In E/UT X, for example, the INPUT X circuit provides count signals, while the clock pulse generator provides start and stop signals. See Section 2.6 for specific information on the individual modes of operation.

2.2 APPLYING POWER

The instrument is ready for use as it arrives from the factory. Connect the power cord to a 117v ac, 50-60 cps, outlet. The crystal oven and oscillator circuits energize immediately, and the instrument is ready for operation. After about 72 hours of operation, the oscillator will meet its stability specification. Therefore, if the instrument is used intermittently, leave the power cord connected at all times to avoid waiting for crystal warm-up.

NOTE

> Do not remove the Model 696 Basic Plug-in unless other plug-ins are used. Each plug-in completes certain circuits in the instrument that are essential for operation.

2.3 TYPES OF MEASUREMENT

The Model 6144 makes three basic measurements in addition to manually gated counting.

1) It counts the number of events occurring during a precise time interval. This is E/UT operation. Frequency measurements are made in this mode.

2) It measures the time interval between two events. For Time Interval Measurement (TIM) the two events occur on separate input channels. For PERIOD measurements the two events occur on the same input channel. If the interval at the same input is multiplied by some factor (10, 10^2, etc.), thus extending the counting period, the operation is known as MULTIPLE PERIOD.

3) It counts the number of events at one input during the interval between consecutive events at the other input. This mode of operation is known as Ratio (more specifically, frequency ratios). Ratio measurements are made in two ways: (a) UNITS Y/PERIOD X, (b) UNITS Y/MULTIPLE PERIOD X.

2.4 OPERATING CONTROLS AND CONNECTORS

Operating controls and connectors are described in Table 2-1.

Table 2-1

Name	Function
POWER Switch	Turns power on when turned to LATCH or FOLLOW.
FOLLOW Position	Part of POWER switch. Causes EL reading to continually update its presentation during count interval, and then hold reading into next count interval.

Table 2-1 (continued)

Name	Function
LATCH Position	Part of POWER switch. Readout displays the total count of each counting interval and holds it without change until there is a new total count.
TIME Selector	Selects Gate Time for E/UT and TEST measurements. Also selects TIME Units in which measurement appears for 1 PERIOD X, MULTIPLE PERIOD X, and TIM X-Y. Selects INPUT Y Circuit for ratio measurement.
MODE Selector	Interconnects logic blocks to perform the measurement indicated.
ATTEN FACTOR Control	Attenuates the signal and dc level at the input jack by the factor to which the control is set. Selects ac or dc input coupling to the attenuator.
TRIGGER Control	Selects the instantaneous voltage at which the input signal causes the input trigger circuit to generate an output pulse.
SLOPE Switches	Determine which slope (positive or negative) of the input signal will start or stop the counting action.

Table 2-1 (continued)

Name	Function
RECYCLE RATE Control	Controls the rate at which the instrument will sample new data. In MAX position, counter recycles at a maximum rate. Set to MAN, instrument recycle is manually controlled by pressing RESET push-button.
Manual RESET Pushbutton	With latched indication the RESET control performs either of two functions dependent upon whether the Count Gate is closed or open. 1) Closed - accumulated data is transferred to the DSU's and presented on the EL display and a new count accumulated. 2) Open - instrument is reset to zero and a new count accumulated. Stored data is retained. With FOLLOW indication the RESET control causes instrument to reset to zero and accumulate a new count.
INPUT Jacks	For signal inputs to INPUT's X and Y.
GATE OPEN Light	Light is on when count gate is open. Provides additional visual indication of counter recycle.

NOTE

See Auxiliary Connectors, Section 2.9, for information on connectors used in special variations of the standard operating procedure.

2.5 TESTING FOR PROPER OPERATION

The self-checking procedure is simple, quick, and may be performed each time the instrument is energized.

1) Set POWER switch to LATCH.

2) Turn RECYCLE RATE control fully clockwise to obtain a maximum recycle rate.

3) Turn MODE selector to TEST.

4) Turn TIME selector to each time position starting with 1 μsecond and continuing to 10 seconds. Correct count indications are shown in Table 2-2.

Table 2-2

TIME SELECTOR POSITION	CORRECT COUNT INDICATIONS		
1 μsec.	0000000	0000001	0000002
10 μsec.	0000009	0000010	0000011
0.1 msec.	0000099	0000100	0000101
1 msec.	0000999	0001000	0001001
10 msec.	0009999	0010000	0010001
0.1 sec.	0099999	0100000	0100001
1 sec.	0999999	1000000	1000001
10 sec.	9999999	0000000	0000001

5) If a correct count indication appears at all positions, the instrument is operating properly.

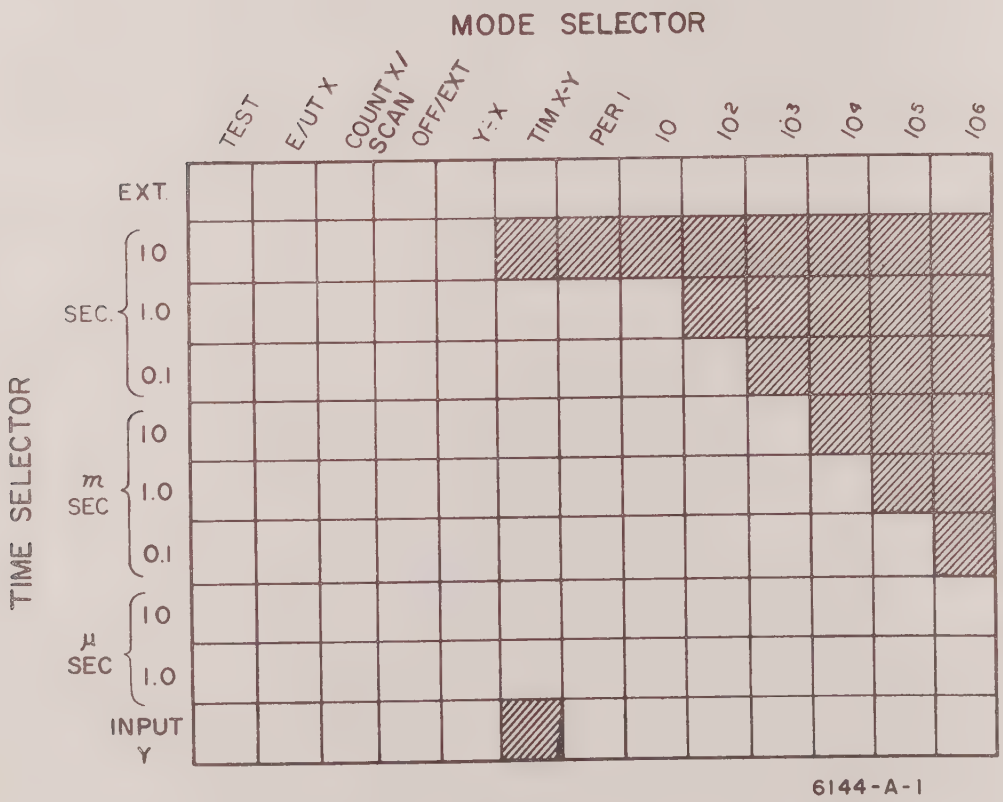
6) Instrument may be tested in FOLLOW to observe count change. Retard RECYCLE RATE control to approximately 1 reading per second for best observation.

2.5.1 EL Indicator Panel Check

To visually test the EL indicator panel, place the MODE selector in 10^6 MULTIPLE PERIOD X and the TIME selector in any position from 1.0 μseconds to 10 seconds. All eights will appear on the panel showing the 7-bar configuration of each of the 7 digits.

Any incompatible setting of the TIME and MODE selectors will cause all eights to appear on the EL panel. Table 2-3 shows the incompatible positions of the two controls.

Table 2-3



Indicates incompatible positions of the TIME and MODE Selectors (all eights appear on the readout)

As shown in Table 2-3, the TIM X-Y and 1 PERIOD X modes are made incompatible with a 10 second time base. The long time duration needed between start and stop pulses, to allow enough counts (1 count/10 seconds) to be accumulated by the DCU's, make these modes of operation impractical. For example, in order to count ten clock pulses from the time base, the start and stop pulses would have to be separated by 100 seconds.

Table 2-3 also shows that MULTIPLE PERIOD positions (10, 10^2, etc,) of the MODE selector are incompatible with certain positions of the TIME selector. To understand why some TIME and MODE selector positions are incompatible, it is first necessary to understand the operation of the DCU divider chain.

The DCU divider chain serves as time base dividers, or as dividers for MULTIPLE PERIOD operation. Each DCU in the divider chain performs one function, i.e., to divide its input by 10. The DCU cannot simultaneously divide clock pulses, and also divide a series of pulses from the INPUT X circuit in some MULTIPLE PERIOD position. Therefore, the DCU can only be used for one function at a time.

Thus, incompatible positions occur when the same DCU is selected for simultaneous use as a time base divider and as a divider for MULTIPLE PERIOD operation.

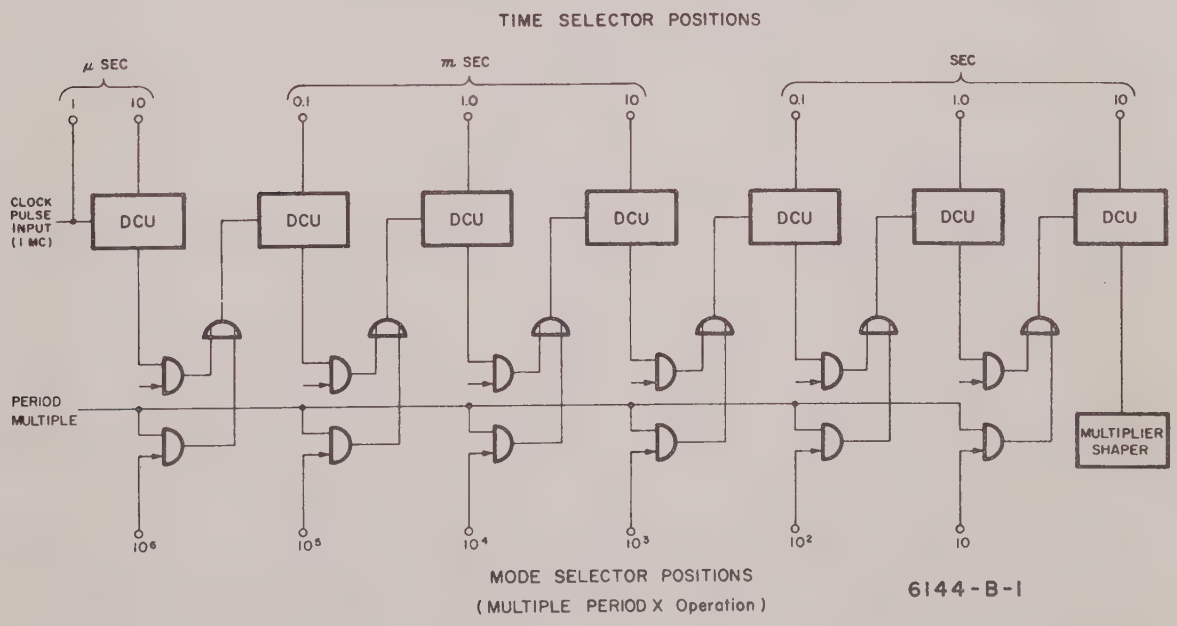


FIG. 2-1. Simplified Block Diagram of DCU Divider Chain.

For example, setting the TIME selector to 1 mSEC and the MODE selector to 10^5 PERIOD X causes the same DCU to perform two functions. This results in an incompatible position. Figure 2-1 shows the logic of the DCU divider chain.

With the TIME selector in UNITS Y and the MODE selector in TIM X-Y, eights appear in the readout. Input Y provides the pulse to close the count gate; therefore, any pulse that could be counted would also close the gate.

2.6 MODES OF OPERATION

Refer to Table 2-4.

Table 2-4

Modes of operation	What the instrument does in each mode
TEST	Counts 1.0 mc oscillator output during each timing interval.
E/UT X	Counts events at INPUT X during a time unit selectable between 1 μsecond and 10 seconds by TIME selector (frequency measurement).
COUNT X/SCAN	SCAN: Counts events at INPUT X during manually controlled multiples of the time base. COUNT X: Counts events at INPUT X during manually controlled counting period.
OFF	For manual control of COUNT X.
Y ÷ X	Measures ratio of INPUT Y frequency to INPUT X frequency (number of events at INPUT Y during one event at INPUT X).

Table 2-4 (continued)

Modes of operation	What the instrument does in each mode
TIM X-Y	Time Interval Measurement - Measures the interval between an event at INPUT X and an independent event at INPUT Y. Time units (1 μsec. to 1 sec.) selected by TIME selector.
PERIOD X	1 PERIOD X: Measures the time interval between consecutive events at INPUT X. Time units (1 μsec. to 1 sec.) selected by TIME selector. MULTIPLE PERIOD X: Measures the time interval between multiple events ($10, 10^2, \ldots 10^6$) at INPUT X.
Ratio	UNITS Y/1 PERIOD X: TIME selector set to UNITS Y, and MODE selector to 1 PERIOD X. Measures ratio of INPUT Y frequency to INPUT X frequency (number of events at INPUT Y during one event at INPUT X). UNITS Y/MULTIPLE PERIOD X: TIME selector set to UNITS Y, and MODE selector to one of the MULTIPLE PERIOD positions ($10, 10^2, \ldots 10^6$). Measures ratio of INPUT Y frequency to multiples of INPUT X frequency.

2.6.1 E/UT X MODE

With the MODE selector in E/UT X, the instrument counts events at INPUT X during unit of time selectable between 1 μsecond and 10 seconds (frequency measurements). The functional blocks connect as shown in Figure 2-2.

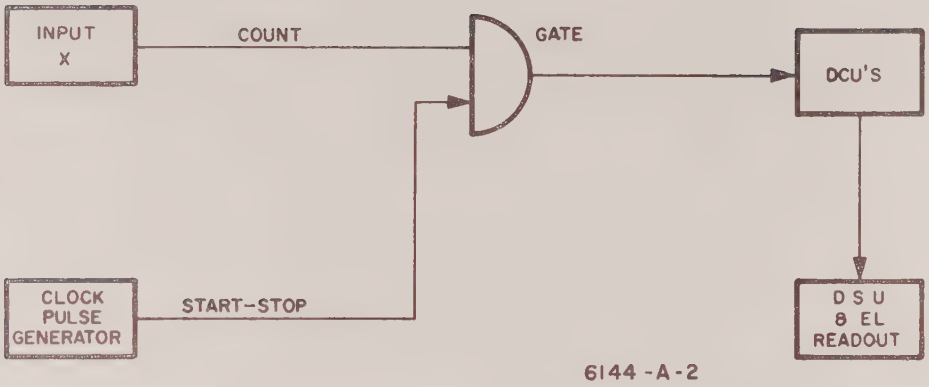


FIG. 2-2. E/UT X MODE.

Operating Procedure

1) Connect the input signal to the INPUT X. Adjust the ATTEN control as described in Section 2.7.7.

2) Turn the MODE selector to E/UT X.

3) Set the TIME selector to the time interval over which events are to be counted. A longer time base will increase the number of digits displayed, thus increasing measurement accuracy.

4) Adjust RECYCLE RATE control for a convenient reading or recording rate.

5) The readout displays count, units, and decimal point

2.6.2 SCAN

Counts events at INPUT X during manually controlled multiples of the time base setting. The SCAN function provides a method of measuring low frequencies accurately without resorting to period measurement. The functional blocks connect as shown in Figure 2-3.

1) Connect the input signal to INPUT X. Adjust ATTEN control as described in Section 2.7.7.

2) Switch RECYCLE RATE control to MAN.

3) Turn MODE selector to E/UT X.

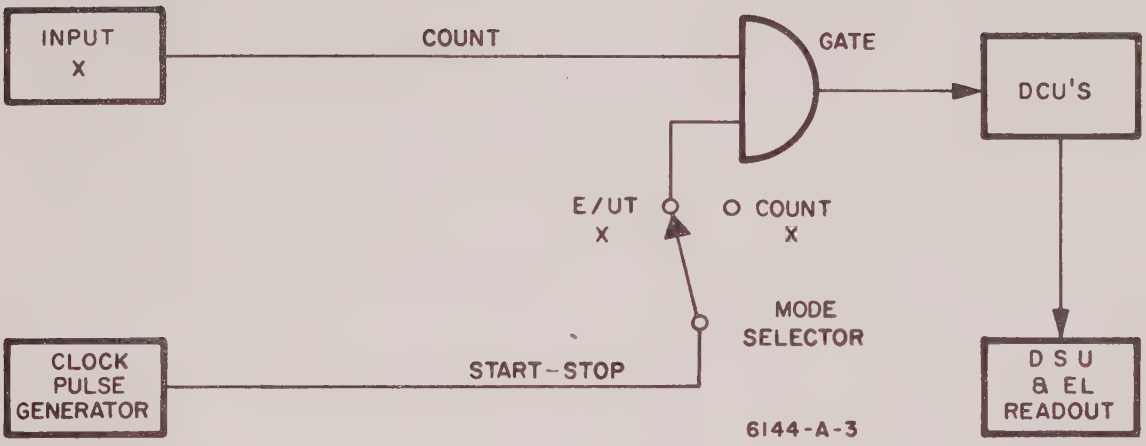


FIG. 2-3. SCAN

4) Turn TIME selector to 10 SEC.

5) Turn POWER switch to either LATCH or FOLLOW.

6) Press the RESET pushbutton to start the counting action, and begin timing the desired number of period measurements. With TIME selector in 10 SEC, each timing period is 10 seconds.

7) Quickly turn MODE selector to COUNT X. Continue timing the periods.

8) Approximately half-way through the last timing period, turn the MODE selector back to E/UT X. Counting will stop with the next stop pulse.

9) Count remains on EL display until instrument is manually recycled.

10) To obtain the input frequency in events per second, divide the count indication by the total counting interval in seconds. Example: If the count displayed is 10,000 and the number of timing periods is 100 (10 seconds times 10 periods = 100), the input frequency in events per seconds is 100

11) To start a new measurement, repeat steps 6, 7, 8, and 9.

2.6.2 COUNT X MODE

With the MODE selector at COUNT X, the instrument counts events at INPUT X during manually controlled counting period. The functional blocks connect as shown in Figure 2-4.

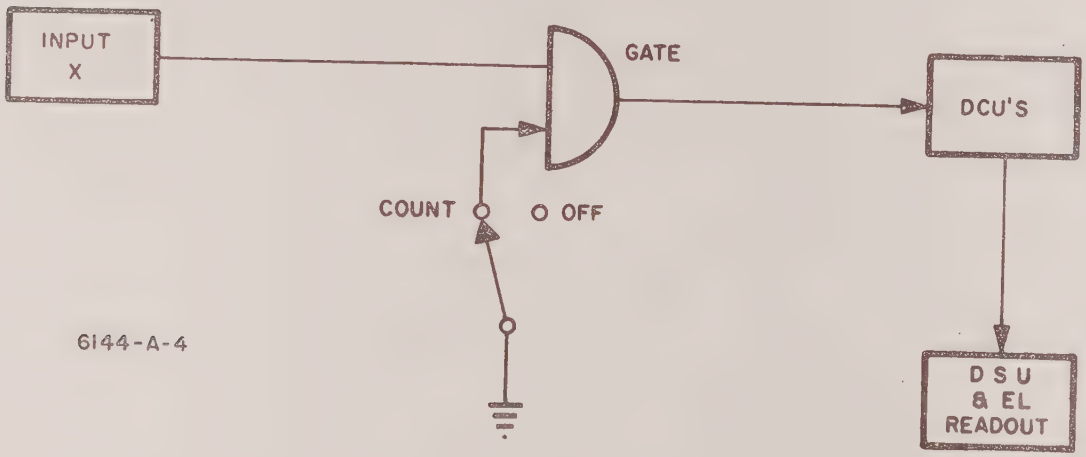


FIG. 2-4. COUNT X MODE.

Operating Procedure

1) Connect input signal to the INPUT X jack. Adjust the ATTEN control as described in Section 2.7.7.

2) Turn MODE selector to OFF.

3) Press manual RESET button. This resets counter to zero.

4) Turn MODE selector to COUNT. This begins the counting action. The input channel will trigger only on the negative slope of the input waveform.

5) Turn MODE selector to OFF to stop the counting. The GATE OPEN light will stay on continuously in this mode of operation.

6) Read the count indication. To continue counting without erasing the previous indication, turn MODE selector back to COUNT.

2.6.4 TIM X-Y MODE

With the MODE selector in TIM X-Y, the instrument measures the interval between an event at INPUT X and an independent event at INPUT Y. The functional blocks connect as shown in Figure 2-5.

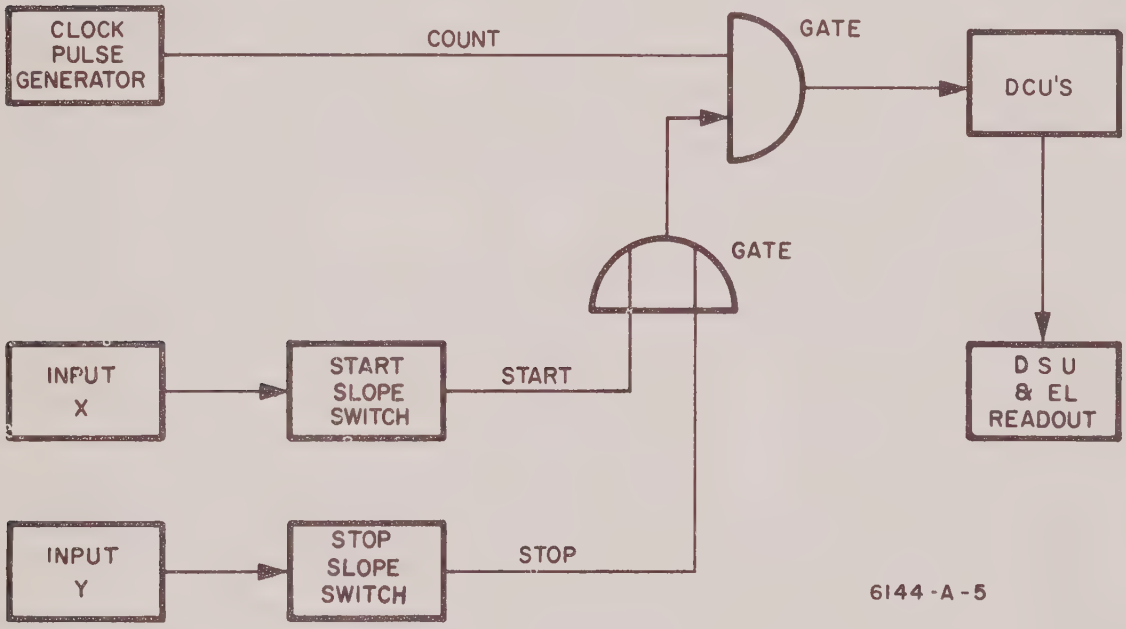


FIG. 2-5. TIM X-Y MODE

Operating Procedure

1) Connect the stop signal to INPUT Y. Adjust INPUT Y TRIGGER control as described in Section 2.7.8.

2) Connect the start signal to INPUT X. Adjust INPUT X TRIGGER control as described in Section 2.7.7.

3) Turn MODE selector to TIM X-Y.

4) The START and STOP SLOPE switches select the polarity of the voltage excursion that starts and stops the counting period, respectively.

5) Set the TIME selector to the desired unit of time measurement. For example, at the 1 mSEC position the time measurement appears with one millisecond resolution. The smaller the time unit chosen, the greater the resolution.

6) Adjust the RECYCLE RATE control for a convenient reading or recording rate.

7) The readout automatically displays count, units, and decimal point.

2.6.5 PERIOD Measurement

2.6.5.1 PERIOD X MODE

With the MODE selector in 1 PERIOD X, the instrument measures the interval between consecutive events at INPUT X. This mode measures the period of a cyclical waveform, the width of a pulse, or separation of pulses. The functional blocks connect as shown in Figure 2-6.

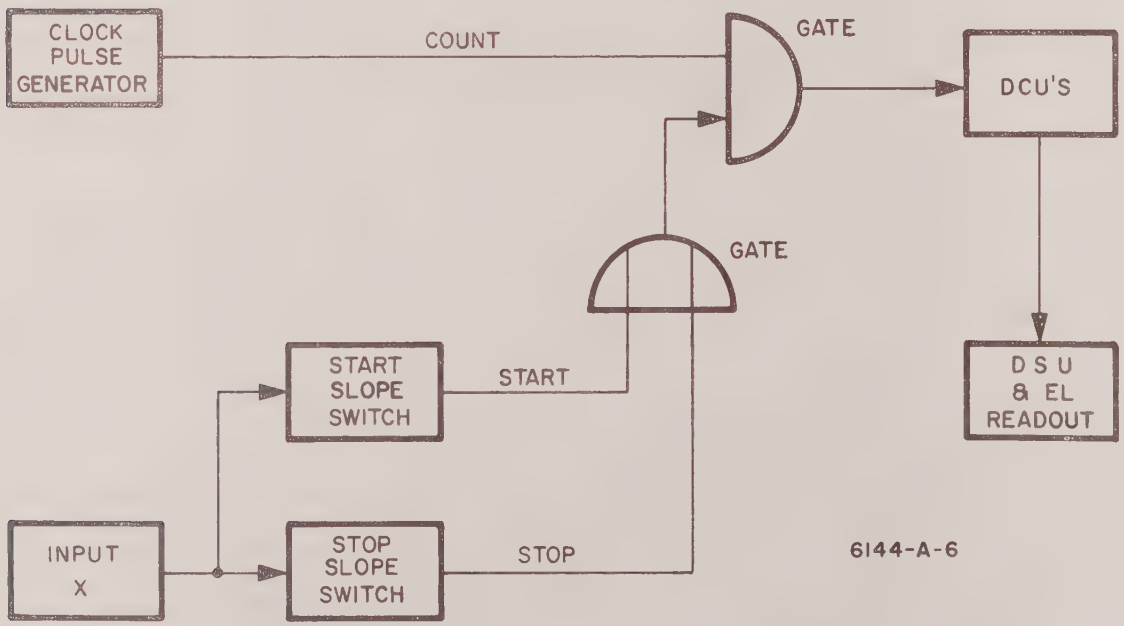


FIG. 2-6. PERIOD X MODE.

Operation Procedure

1) Connect input signal to INPUT X. Adjust the ATTEN control as described in Section 2.7.6. An oscilloscope may be required to position trigger points on asymmetrical waveforms. A SCOPE jack on the rear panel provides an output representing the Count Gate. Triggering the oscilloscope at the opening or closing of the Count Gate while monitoring the input waveform, permits the operator to see the start or stop points on the input waveform.

2) Turn MODE selector to 1 PERIOD X.

3) The START SLOPE switch selects the polarity of the voltage excursion that starts the timing period; the STOP SLOPE switch selects the polarity of the excurstion that stops timing. Therefore,

   a) To measure the period of a cyclical waveform, set both SLOPE switches to "+" or both to "-".

   b) To measure the width of a positive waveform, set the START SLOPE switch to "+" and the STOP SLOPE switch to "-".

   c) To measure the width of a negative waveform, set the START SLOPE switch to "-" and the STOP SLOPE switch to "+".

   d) To measure positive pulse separation, set the START SLOPE switch to "-" and the STOP SLOPE switch to "+", or vice versa for negative pulses.

4) Switch the TIME selector to the desired unit of time measurements. For example, at the 1 mSEC position the time measurement appears with one millisecond resolution. The smaller the time unit chosen, the more accurate the reading within limits of period accuracy.

5) Adjust the RECYCLE RATE control for a convenient reading or recording rate.

6) Readout automatically displays count, units, and decimal point.

2.6.5.2 MULTIPLE PERIOD X MODE

With the MODE selector at one of the MULTIPLE PERIOD positions (10, 10^2, . . . 10^6), the instrument measures the interval between multiple events at INPUT X. These settings will measure the period of an event more accurately than 1 PERIOD X by averaging a greater number of periods over which counting occurs. The functional blocks connect as shown in Figure 2-7.

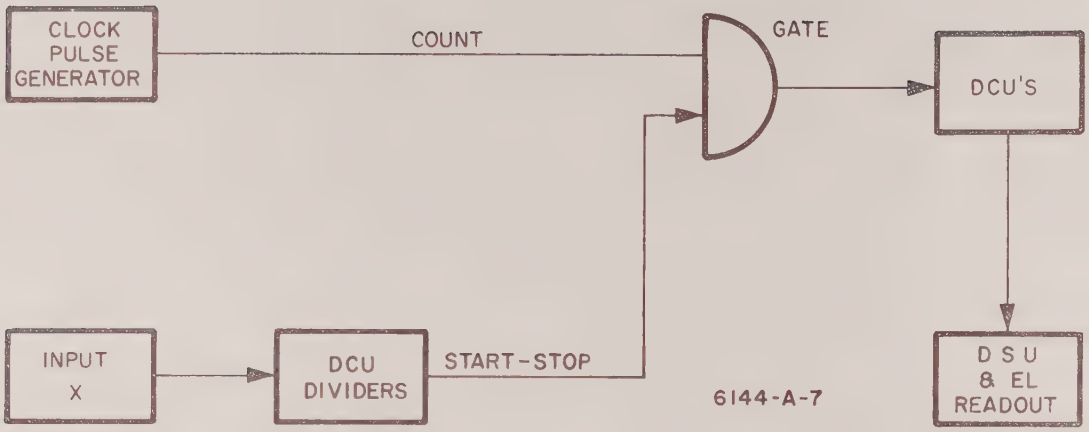


FIG. 2-7. MULTIPLE PERIOD X MODE.

Operating Procedure

1) The INPUT X TRIGGER adjustment is made the same as in 1 PERIOD X. The maximum frequency that can be used in MULTIPLE PERIOD X is 300 kc as limited by the DCU dividers.

2) Select a position (10, 10^2, . . . 10^6) on the MODE selector. The larger the number, the greater the number of periods over which counting will be averaged.

3) Set the TIME selector to desired unit of time measurement. The smaller the time unit chosen, the greater the resolution.

NOTE

There are certain positions of the TIME and MODE selectors that are incompatible. See Table 2-2.

4) INPUT X triggers only on the negative slope of the input waveform.

5) Adjust the RECYCLE RATE control for a convenient reading or recording rate.

6) Readout automatically displays count, units and decimal point.

2.6.6 Ratio Measurements

2.6.6.1 UNITS Y/PERIOD X MODE

With the MODE selector in 1 PERIOD X and TIME selector in UNITS Y, the instrument measures ratio of INPUT Y frequency to INPUT X frequency (number of events at INPUT Y during one event at INPUT X). Functional blocks connect as shown in Figure 2-8.

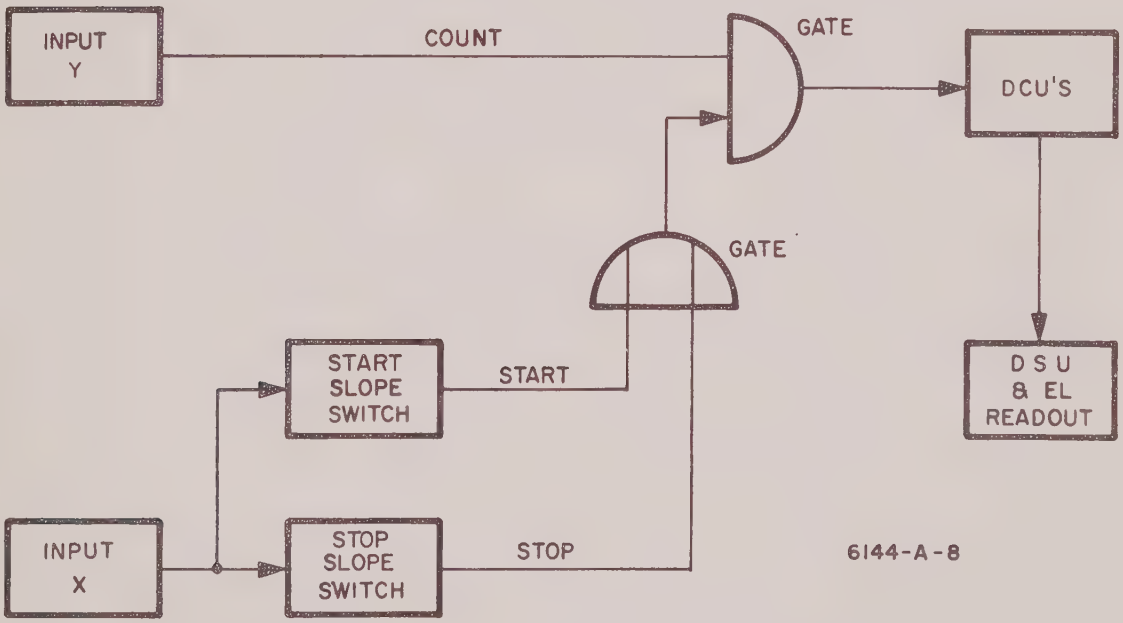


FIG. 2-8. UNITS Y/PERIOD X MODE.

Operating Procedure

1) Connect the higher frequency to the INPUT Y. Adjust INPUT Y ATTEN control as described in Section 2.7.8.

2) Connect the lower frequency to the INPUT X. Adjust INPUT X ATTEN control as described in Section 2.7.7.

3) Switch MODE selector to 1 PERIOD X, and the TIME selector to UNITS Y.

4) The START SLOPE switch determines the polarity of the voltage excursion that starts the counting period. The STOP SLOPE switch sets the polarity of the voltage excursion that stops the counting period. Therefore,

   a) When measuring the ratio of two frequencies set both SLOPE switches to "+" or both to "-".

   b) When counting the INPUT Y during the period that INPUT X voltage remains below a certain negative level, set the START SLOPE switch to "-" and the STOP SLOPE switch to "+".

5) The INPUT Y triggers on a negative-going input.

6) Adjust the RECYCLE RATE control for a convenient reading or recording rate

7) The readout automatically displays count information.

2.6.6.2 UNITS Y/MULTIPLE PERIOD X

With the MODE selector in one of the MULTIPLE PERIOD X positions and the TIME selector in UNITS Y, the instrument measures ratio of INPUT Y to multiple events at INPUT X. Ratio measurements are more accurate using multiple periods because a greater number of periods are averaged over which INPUT Y is counted. Functional blocks connect as shown in Figure 2-9.

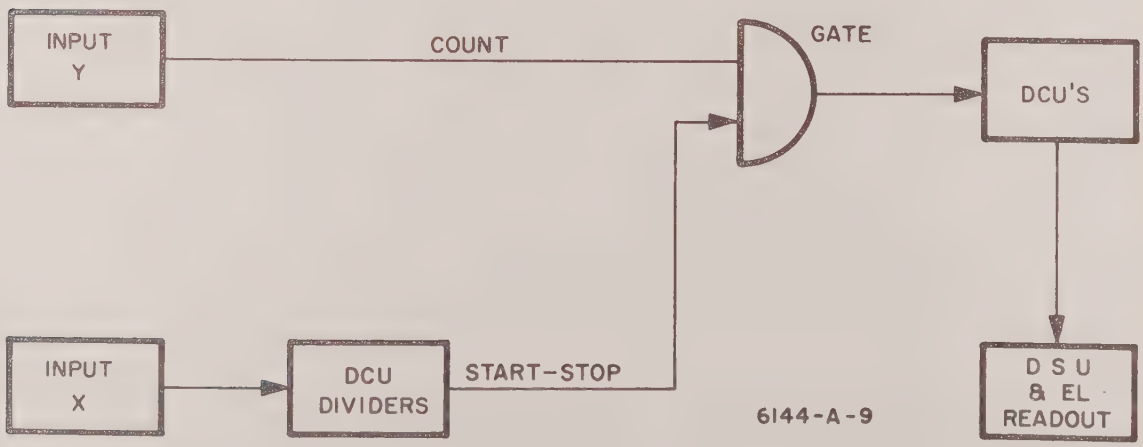


FIG. 2-9. UNITS Y/MULTIPLE PERIOD X.

Operating Procedure

1) Set up the input channels as in UNITS Y/1 PERIOD X.

2) Turn MODE selector to some position of MULTIPLE PERIOD X (10, 10^2, . . . 10^3, etc.). The number of periods selected determines the number of events required at INPUT X to start and stop counting. Counting starts and stops on the negative-going slope of the INPUT X signal for periods of 10 through 10^6.

3) Switch TIME selector to UNITS Y. The INPUT Y channel triggers on the negative-going input signal.

4) Adjust RECYCLE RATE for a convenient reading or recording rate.

5) The readout displays count information and automatically places the decimal.

2.6.6 Y ÷ X MODE

With MODE selector in Y ÷ X, the instrument measures ratio of INPUT Y frequency to INPUT X frequency (number of events at INPUT Y during one event at INPUT X). When used with the Transfer Oscillator, the TIME selector is used to select a desired frequency from the time base with output available at the rear panel.

2.7 INPUT'S X AND Y

Information in this section applies to both INPUT's X and Y, since these input circuits are identical. Figure 2-10 is a block diagram of one of these input circuits.

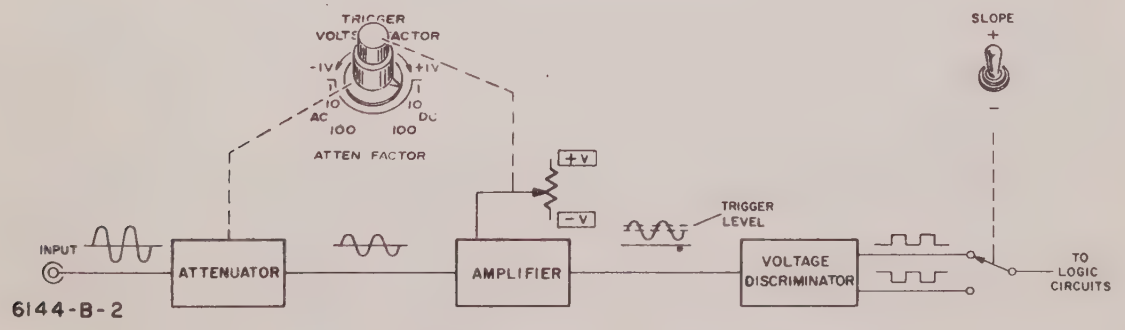


FIG. 2-10. Simplified Input Circuit Block Diagram.

2.7.1 ATTEN FACTOR Control

2.7.2 Input Coupling

The ATTEN FACTOR selector selects AC or DC coupling and input attenuation. In the DC position the dc (plus the ac component of the input signal) couples to the attenuator. Switching to AC places a .02 μf, 600 vdc capacitor between the input jack and the attenuator permitting only the ac component of the input to reach the attenuator. The equivalent input circuit is 1 megohm for all ATTEN FACTOR positions. The input circuit is shunted with approximately 40 pf at each attenuator position. A typical drift figure at the DC "1" position is 3 mv/°C.

2.7.3 Attenuation

Each position of the ATTEN FACTOR control divides the input signal by the factor indicated (1, 10, and 100). Effectiveness of the TRIGGER control depends on the correct use of the ATTEN FACTOR control. Since these two controls are interdependent, the use of the ATTEN FACTOR control is discussed with the TRIGGER control in Section 2.7.4.

2.7.4 The TRIGGER Control

As shown in Figure 2-10, the TRIGGER control is part of the amplifier, and determines the voltage at which an input signal causes the input circuits to generate an output pulse. The amplifier output signal drives a voltage discriminator circuit. The discriminator exhibits a characteristic known as hysteresis. Hysteresis is a small, fixed voltage range, centered around a fixed dc level at the discriminator's input. When a voltage change passes through this hysteresis range, the discriminator output changes voltage levels (Figure 2-11A). This voltage level remains until a voltage change again passes back through this hysteresis range, at which time the discriminator's output returns to its original state (Figure 2-11B).

The amplifier output is shifted by the TRIGGER control in either a positive or negative direction to allow the operator to choose a particular point on the waveform to trigger the discriminator circuit. As long as the amplitude of the voltage change is large enough to pass through the hysteresis range, triggering will occur.

For example, with the ATTEN FACTOR control in AC "1", the TRIGGER control adjustment range is ±1 volt; that is, it can shift a signal referenced at the input over a ±1 volt range at the discriminator's input. Using a 10 volt p-p input, the ±1 volt adjustment range is not adequate to shift the 10

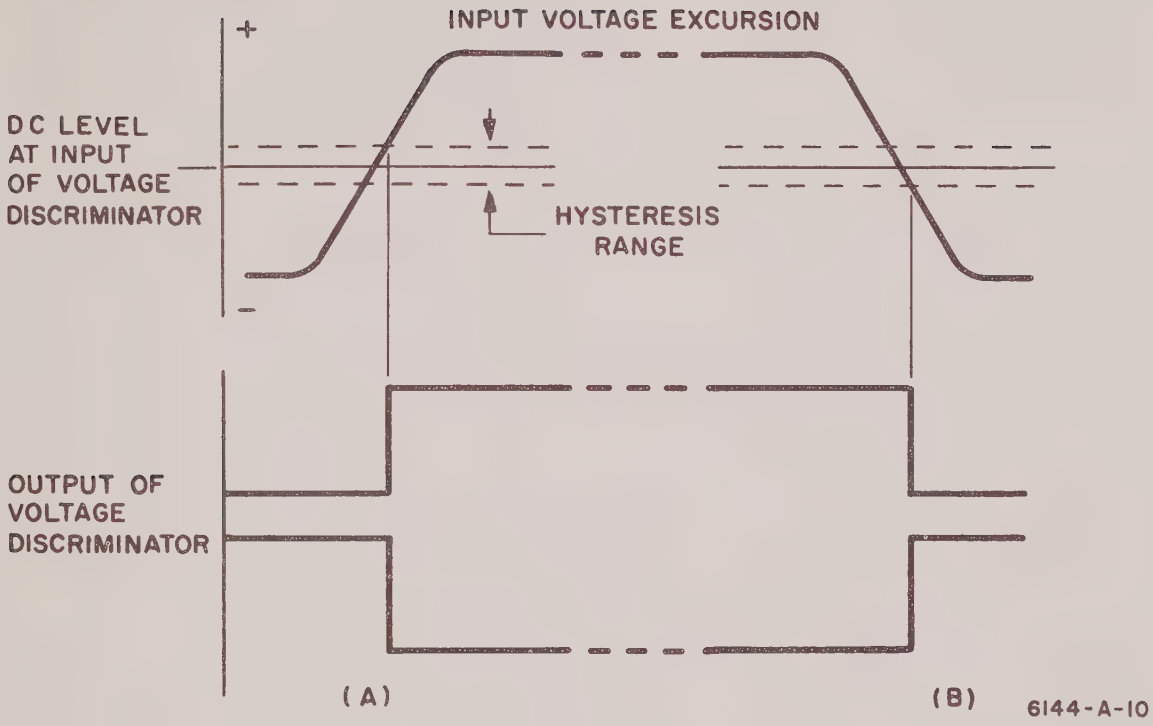


FIG. 2-11. Shows output of voltage discriminator as a voltage change passes through hysteresis range.

volt p-p signal enough in a positive or negative direction to permit any desired part of the signal to pass through the hysteresis range of the discriminator circuit (see Figure 2-12A). Therefore, the ATTEN FACTOR control becomes important. By setting the ATTEN FACTOR control to AC "10", the input signal driving the amplifier is attenuated by a factor of 10, thus the signal driving the amplifier is 1 volt p-p. A 1 volt p-p signal can be shifted enough so the desired part passes through the hysteresis range of the discriminator circuit (see Figure 2-12B).

The input signal is reduced to fall within the range of the TRIGGER control. Therefore, effective range of this control is multiplied by the setting of the ATTEN FACTOR (i.e., 10, 100).

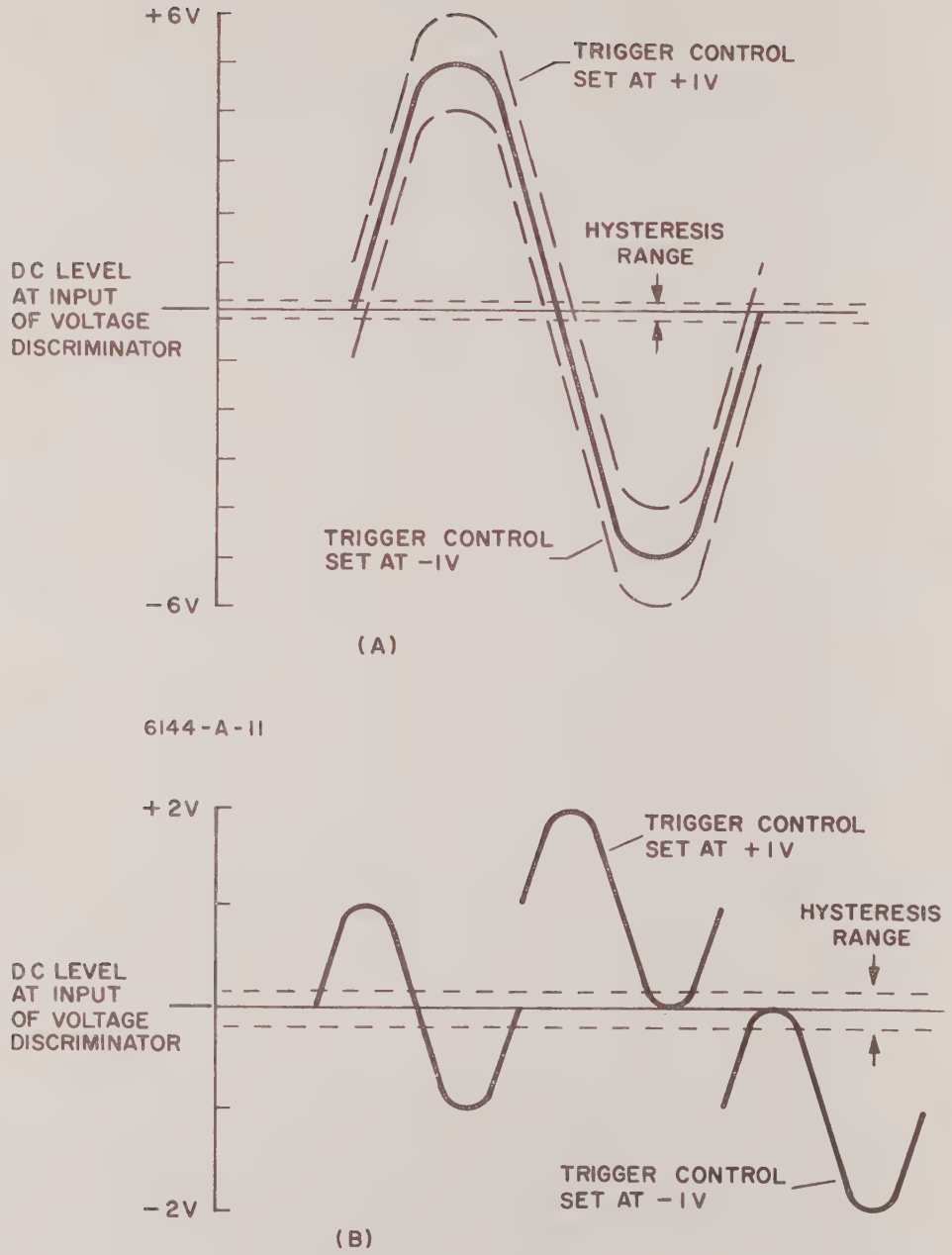


FIG. 2-12. (A) shows that the TRIGGER control range is not enough to shift any part of the input signal through the hysteresis range of the voltage discriminator; (B) shows the signal attenuated enough so it passes through this range.

For dc coupled signals, the dc level (plus the ac component) has to be considered in adjusting the ATTEN FACTOR and TRIGGER controls. If the dc level is large, the ac component may never be within range of the TRIGGER control; therefore, the ATTEN FACTOR control may have to be set to 10, or 100. However, since the ac component is also attenuated, it may then be less than minimum sensitivity of the discriminator circuit.

2.7.5 SLOPE Switches

The SLOPE switch determines which slope (positive or negative) of the input signal will start or stop the counting.

Figure 2-13 shows the input signal slopes in relation to the discriminator output pulse.

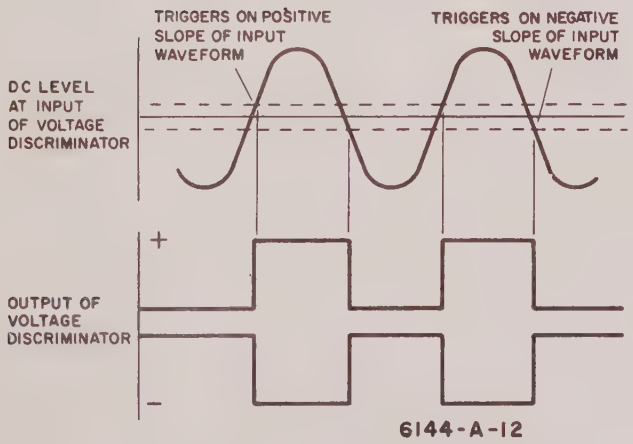

TRIGGERS ON POSITIVE SLOPE OF INPUT WAVEFORM
TRIGGERS ON NEGATIVE SLOPE OF INPUT WAVEFORM
DC LEVEL AT INPUT OF VOLTAGE DISCRIMINATOR
+
OUTPUT OF VOLTAGE DISCRIMINATOR
-
6144-A-12

FIG. 2-13.

Shows output of voltage discriminator with sine wave input; also relationship of input signal slope to voltage discriminator output.

Logic circuits in this instrument respond only to positive going slopes of the voltage discriminator output; therefore, it is possible to select the desired slope of the input signal to operate the instrument.

For example, the period of a sine wave can be determined by setting both SLOPE switches to "+" or "-". The positive slopes of the input waveform correspond to the "+" setting of the SLOPE switch and to the positive-going slope of the positive output pulse of the discriminator. The negative slopes of the input waveform correspond to the "-" setting of the SLOPE switch and to the positive-going slope of the negative output pulse of the discriminator.

2.7.6 Using the TRIGGER control

The purpose of the input trigger channel is to produce a reliable pulse output representing a selected part of the input signal. Proper adjustment of the ATTEN FACTOR and TRIGGER controls ensures this condition. Before adjusting the controls, try to visualize the input waveform, noting the ac amplitude and dc level. The effect of various control settings is as follows:

1) If the attenuated signal is small (p-p), the trigger voltage level may be set too high or too low to produce a pulse.

2) If the attenuated voltage variations "ride" on a dc level, they may not come within the trigger voltage range.

3) Modulation or other variation of the attenuated signal is least likely to cause trigger failure if the trigger voltages are set about halfway between the peaks of the signal.

4) Extraneous signals (noise or modulation) have the least effect on the time at which a pulse occurs when the input circuit triggers on a steep slope of the waveform.

5) Noise below the range of the trigger circuit will not trigger extraneous pulses. Consequently, attenuating a noisy signal may reduce the effect of the noise.

6) Attenuating the input signal:

   a) Reduces the slope at all points.

   b) Shifts the ac component nearer ground if it rides on a dc level.

   c) Increases the minimum p-p variations necessary to trigger the input circuit (measured at the INPUT).

   d) Increases the range of possible trigger voltage control over the input signal from ±1 volt to ±100 volts.

2.7.7 INPUT X TRIGGER Control Adjustment

1) Set ATTEN FACTOR control to 100.

2) Couple signal to INPUT X.

3) Switch MODE selector to COUNT X.

4) Slowly turn TRIGGER control between its extreme positions, and note whether counting occurs. If counting occurs, proceed to step 6; otherwise, continue on to step 5.

5) Repeat step 4, each time reducing the attenuation factor, i.e., 10, 1, until counting occurs. If no counting occurs in ATTEN "1", determine if an adequate input signal is present.

6) By turning the TRIGGER control, determine the positions which start and stop counting, then set the control midway between two positions. The INPUT X trigger circuit should now be operating properly.

7) Refer back to Mode of Operation section (Section 2.6) for further information on mode being used.

2.7.8 INPUT Y TRIGGER Control Adjustment

1) Make sure no signal is connected to INPUT X.

2) Switch MODE selector to PERIOD X.

3) Switch TIME selector to UNITS Y.

4) Set ATTEN FACTOR control to 100.

5) Connect signal to INPUT Y.

6) Rotate INPUT X TRIGGER control through its range until GATE OPEN light comes on.

7) Slowly turn TRIGGER control between its extreme positions, and note whether any counting occurs. If counting occurs, proceed to step 9; otherwise, continue on to step 8.

8) Repeat step 7, each time reducing the attenuation factor, i.e., 10, 1, until counting occurs. If no counting occurs in ATTEN "1", determine if an adequate input signal is present.

9) By turning the TRIGGER control, determine the positions which start and stop the counting, then set the control midway between these two positions.

10) Refer back to Mode of Operation section (Section 2.6) for further information on mode being used.

2.8 ACCURACY

Accuracy of a measurement depends on the sum of errors contributed from four sources: the gating action, the internal time standard, the input signal (that does not truly represent the event being measured), and the resolution of the instrument.

2.8.1 Error Due to Gating Action

Figure 2-14 shows how gating action may cause the indication to be in error as much as ±1 count. If the gate opens just before one clock pulse and closes immediately after another, the indication may be one time unit high. But if the gate opens just after a pulse and closes just before another, the indication may be one time unit low. In no case will the error be greater than one time unit. In TIM and PERIOD measurement, this error will be very slight if the time units chosen are small in comparison to the interval being timed.

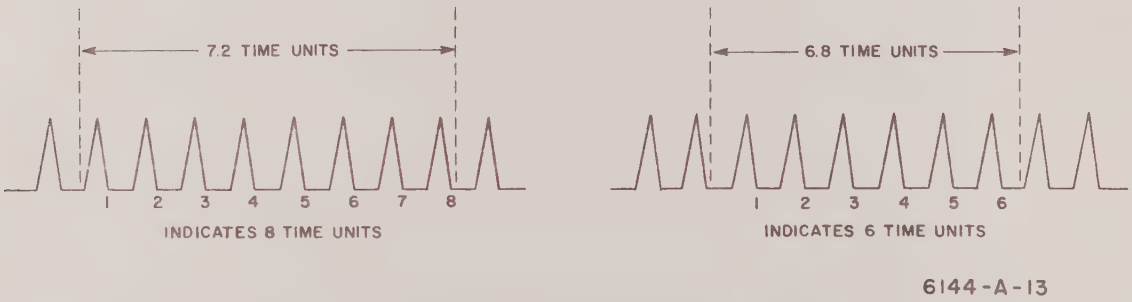


FIG. 2-14. Illustrates how gating action may cause an error of one time unit.

2.8.2 Error Due to Internal Time Standard

The internal time standard is a crystal oscillator housed in a thermostatically controlled chamber. The oscillator is subject to deviations from an absolute standard, and may change frequency during the interval between two calibrations. Once set, the oscillator will not vary more than 3 parts in 10^7 per week. This means that measurements made within the same week can be compared with a maximum error of 0.00002 percent. If absolute (as distinguished from comparative) time is important, the oscillator may be periodically adjusted to correspond with the standard frequencies broadcast from the National Bureau of Standards radio stations, WWV or WWVH.

2.8.3 Error Due to a Non-Representative Input Signal

The instrument begins timing at the instant the input excursion passes through the trigger voltage level. If the input contains "noise (where noise is defined as any voltage variation not representative of the event being timed), the noise may cause the input voltage to reach the trigger level too early. Figure 2-15 shows what happens if the noise is a higher frequency imposed on the ideal input signal.

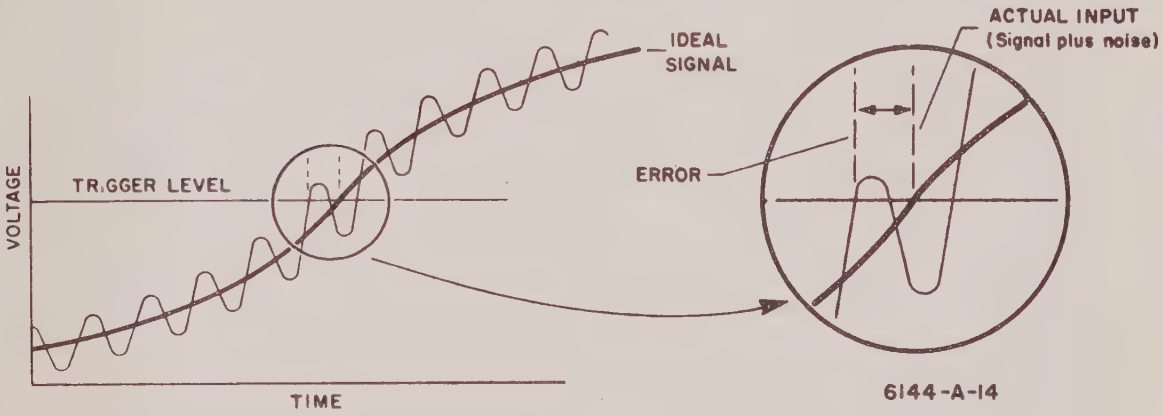


FIG. 2-15. Illustrates how noise may cause a timing error.

The best way to avoid error is to use a noise-free signal of the largest acceptable amplitude. A fast rise time will reduce the error greatly. Figure 2-16 shows that, given two voltage excursions will equal noise, the one with the faster rise time will cause less error.

FIG. 2-16. Illustrates how reducing the rise time of a signal will reduce error due to noise.

The error due to noise can be calculated by the following formula:

$$t = \frac{E_n}{S}, \text{ where}$$

t = maximum possible error in seconds

E_n = peak-to-peak noise in volts

S = slope (volts per second) of ideal signal at trigger point.

2.8.4 Resolution Error

The minimum time that must elapse between events if both are to be counted is called the resolution time of the instrument. This instrument has a resolution time of better than 0.4 microseconds for frequency measurements.

Resolution error becomes important when random events are counted. One such event may occur immediately after another, before the counting circuits are fully recovered and prepared to register it. The second event will not only fail to cause a count but its effect on the circuits may also cause a third event to fail to register.

2.9 AUXILIARY CONNECTORS

2.9.1 Digital Recorder Jack

This multi-terminal socket, wired to the readout lines of each storage binary, makes available 1-2-4-8 binary-coded signals for use with such auxiliary equipment as printers, display units, and data converters. Table 2-5 shows the binary code generated by the storage binaries for each decimal digit registered. A "0" means an output level of about -10 volts with respect to ground and with current limited to 0.2 ma; a "1" means a level at ground or -0.3 volts with respect to ground and with current limited to 5 ma. Table 2-6 lists the pin connections to each storage binary.

Pin 39 carries a control signal from the counter to the recorder. This pin is negative (-10 volts or more) for 50 ms, and at approximately ground potential from the time of reset until the next accessory command.

Pin 40 carries an "inhibit recycle" signal from the accessory to the counter. When this pin is grounded the instrument cannot recycle.

Pins 35 and 38 are grounded.

Pins 29 through 32 are not used.

Table 2-5

FOUR-LINE BINARY CODE				
DECIMAL DIGIT REGISTERED	First Binary Stage (Weight 1)	Second Binary Stage (Weight 2)	Third Binary Stage (Weight 4)	Fourth Binary Stage (Weight 8)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

Use Table 2-5 to convert a coded digit to a decimal digit. Note the weight of each column in which a "1" appears, then sum the weights. For example, the coded digit "1100" is equivalent to 1+2+0+0 = 3; and "1001" is equivalent to 1+0+0+8 = 9.

Table 2-6

	PIN NO. ON DIGITAL RECORDER SOCKET			
	First Binary Stage	Second Binary Stage	Third Binary Stage	Fourth Binary Stage
Highest order digit read	Pin 28	Pin 27	Pin 26	Pin 25
2nd highest order digit	4	3	2	1
3rd highest order digit	8	7	6	5
4th highest order digit	12	11	10	9
5th highest order digit	16	15	14	13
6th highest order digit	20	19	18	17
7th highest order digit	24	23	22	21

2.9.2 TIME Jack

An output signal from the time-base generator is available at this jack. The signal is a +6 volt, 0.15 μsecond pulse in series with 3.3 kohms. These pulses are accurately spaced at the interval indicated by the TIME selector and, except when MODE selector is at TEST or E/UT X, can be used externally as a clock signal. See Figure 2-17.

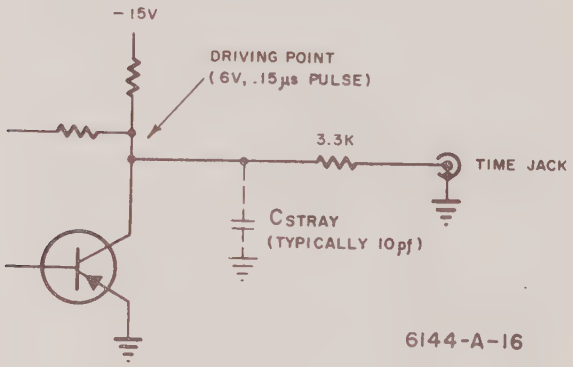


FIG. 2-17. Clock signal output circuit.

2.9.3 FREQ Jack

When the EXT-INT switch is at EXT, an external signal can be introduced at this jack to substitute for the oscillator signal. The external signal must be capable of producing 1 volt rms across 1 kΩ. Frequencies from 50 kc to 2.5 mc are suitable. Frequencies below 50 kc can be used if the internal coupling capacitor is paralleled by a suitable capacitor.

On INT, the oscillator frequency can be monitored.

NOTE

EXT/INT switch must be in INT position for operation of counter unless an external clock is used.

2.9.4 SCOPE Jack

This jack connects through a 15 kΩ resistor to the gate control binary. The voltage at the jack is at ground level when the gate is closed and -10 volts with respect to ground when the gate is open.

2.10 REMOTE PROGRAMMING

Upon request, the instrument can be modified at the factory to include a DPX-57 connector for remote programming. With this modification, external control is possible for the MODE, TIME, RECYCLE RATE controls, and the SLOPE switches.

SECTION 3

SERVICING

3.1 REGULATED POWER SUPPLY ADJUSTMENT

3.1.1 General

There are four adjustments to set the +90, +15, +10, and -15 volt regulated supplies. The +90, +15, and -15 volt adjustments are located on the regulator board and the +10 volt adjustment on the EL supply board. The two boards are located at the rear of the instrument next to the power transformer (see Figure 3-1).

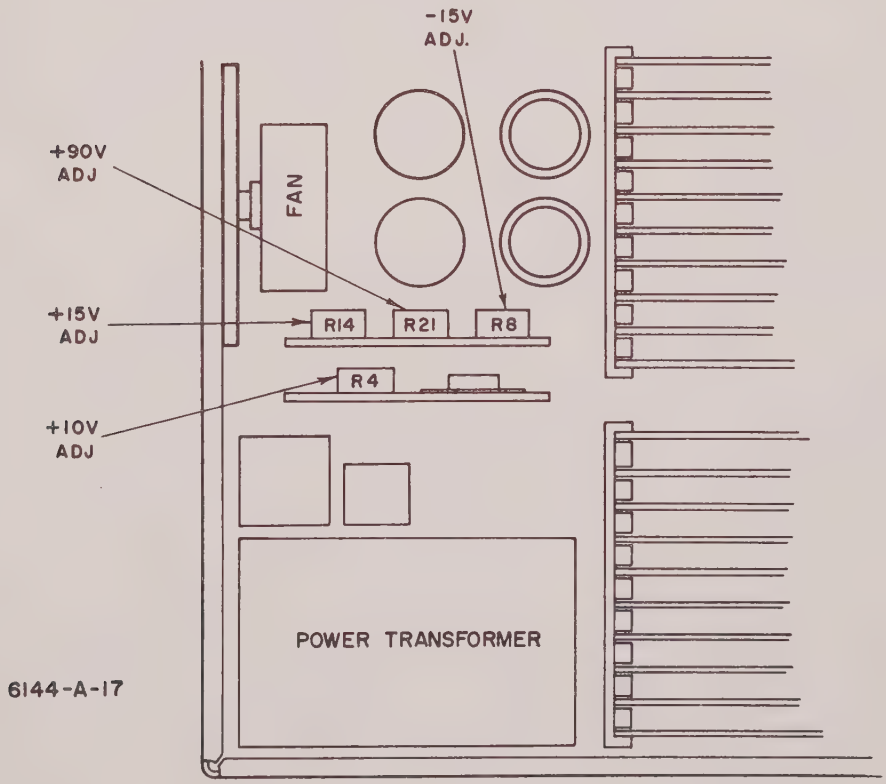


FIG. 3-1. Top view of chassis showing location of +90, +15, +10, and -15 volt adjustments.

3.1.2 Procedure

NOTE

> Do not remove the regulator board from its receptacle without first unplugging the ac line cord from its power source.

1) Use a voltmeter of at least 1% accuracy.

2) Voltage measurements are referenced to chassis ground. See Figure 3-2 for +90, +15, +10, and -15 volt test points.

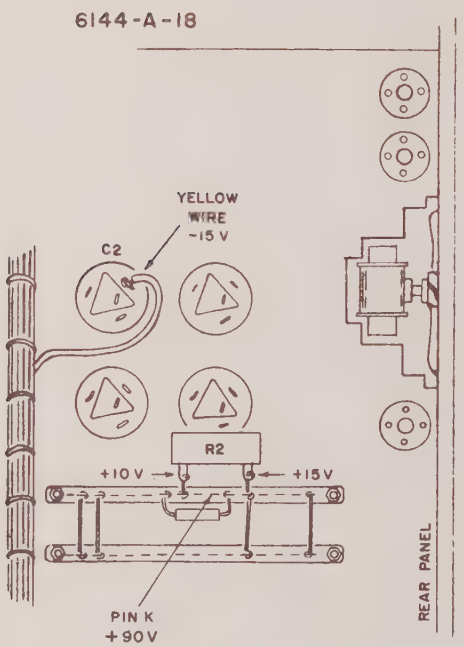


FIG. 3-2. Under chassis view showing location of +90, +15, +10, and -15 volt test points.

3) Remove regulator board from its receptacle. Insert extension board (supplied with instrument) into regulator board receptacle, and insert regulator board at the other end of extension board.

4) Adjust the (+90) potentiometer for +90 volts, ±0.1 volt (see Figures 3-1 and 3-2).

   Adjust the (+15) potentiometer for +15 volts, ±0.2 volt (see Figures 3-1 and 3-2).

   Adjust the (-15) potentiometer for -15 volts, ±0.2 volt (see Figures 3-1 and 3-2).

5) Remove extension board and return regulator board to its receptacle.

6) Remove EL supply board from its receptacle. Insert extension board into EL receptacle and plug EL supply board into other end of extension board.

7) Adjust the (+10) potentiometer for +10 volts, ±0.2 volt (see Figures 3-1 and 3-2).

8) Return EL supply board to its receptacle.

3.2 OSCILLATOR ADJUSTMENT

3.2.1 Procedure

Oscillator adjustments are seldom required. When necessary use this procedure:

1) Adjustment of C1

   a) Use Figure 3-3 to locate trimmer adjustment C1.

   b) Use an oscilloscope (such as Tektronix Model 531) of at least 10 megohms input impedance paralleled with approximately 15 pf; otherwise, loading may change the oscillator frequency.

   c) Connect the output from FREQ Jack J4 to the vertical input of the scope. Then, couple a 1 mc standard to the horizontal input and adjust C1 for a circular Lissajous pattern indicating equal frequencies.

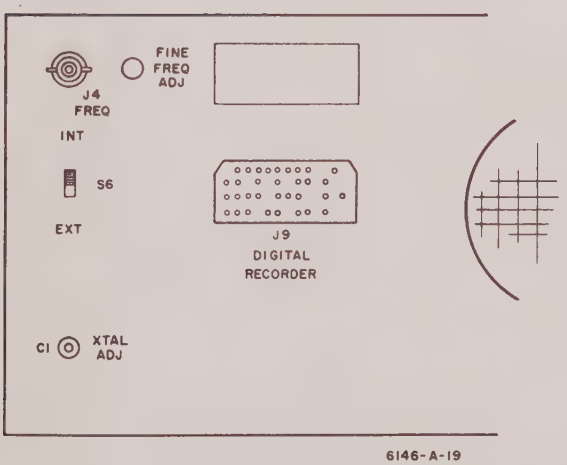


FIG. 3-3. Rear panel view showing location of Crystal Adjust (C1).

3.3 ATTENUATOR ADJUSTMENT

The ceramic trimmer capacitor on each attenuator assembly must be adjusted to prevent the attenuator from distorting the input signal.

3.3.1 Procedure

Refer to Figure 3-4 for location of trimmer adjustments. Equipment needed: Square Wave Generator (Tektronix Type or equivalent), and an Oscilloscope (Tektronix Type 581 or equivalent).

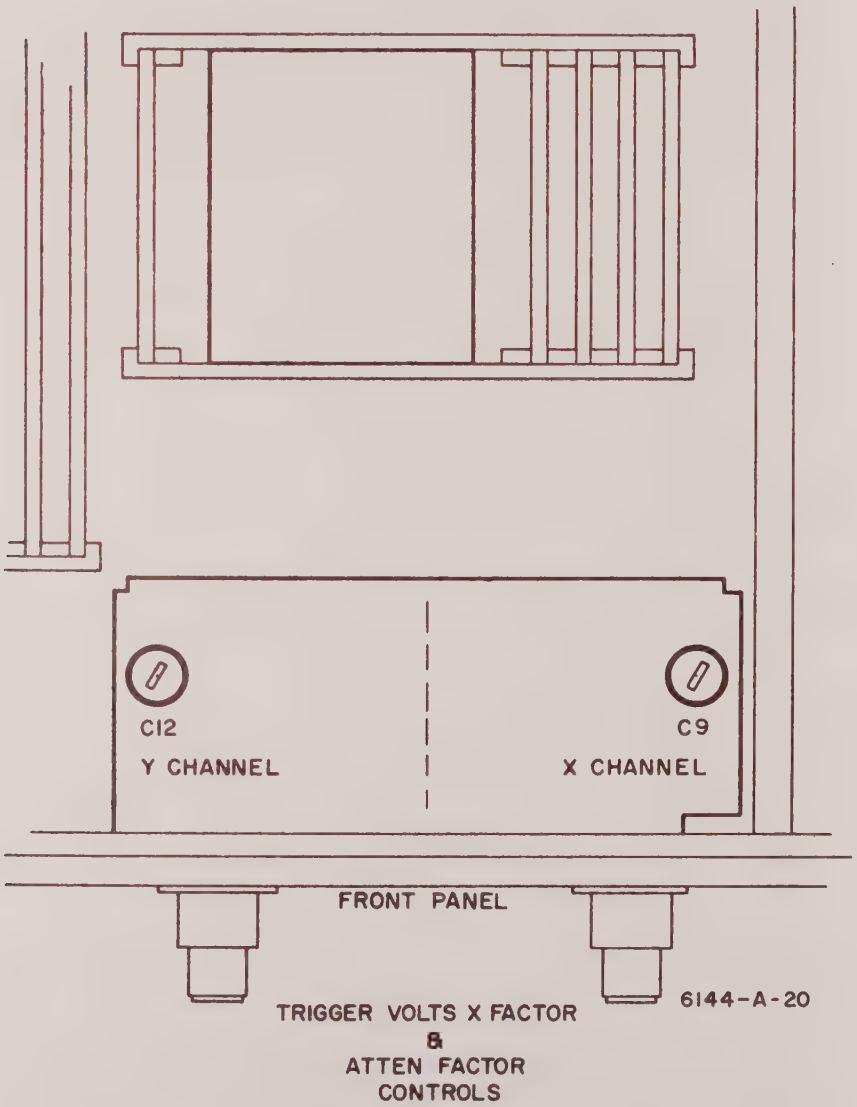


FIG. 3-4. Top view of chassis showing location of ATTEN Selector Frequency compensating capacitors.

1) Make sure both amplifier boards are in place.

2) Connect the Square Wave Generator to INPUT X. Terminate (at instrument) with a 50Ω resistor.

3) Set ATTEN Selector (INPUT X) to AC 10. Apply a 2v p-p, 10kc signal to the input.

4) Monitor with an oscilloscope at pin A of XA18 (input X amplifier) the output of the attenuator. Adjust trimmer C9 for maximum flatness of the square wave.

5) Connect the Square Wave Generator to INPUT Y. Terminate (at instrument) with a 50Ω resistor.

6) Set ATTEN Selector (INPUT Y) to AC 10. Apply a 2v p-p, 10kc signal to the input.

7) Monitor with an oscilloscope at pin A of XA17 (input Y amplifier) the output of the attenuator. Adjust trimmer C12 for maximum flatness of the square wave.

SECTION 4

PARTS LIST

NOTE

The sub-assemblies contained in this parts list are indicated as follows:

Model 860 DCU	P.C. Board A1, A25	"M" Logic	P.C. Board A29
Data Storage Unit (DSU)	P.C. Boards: A2, A4, A6, A8, A10, A12, A14	Time Base Logic	P.C. Board A30
		Legend	P.C. Board A32
Model 850 DCU	P.C. Boards: A3, A5, A7, A9, A11, A13, A19, A20, A21, A22, A23, A24	Recycle	P.C. Board A33
2.5 MC Amplifier	P.C. Boards: A17*, A18	Regulator	P.C. Board A34
"F" Logic	P.C. Board A26	E. L. Supply	P.C. Board A35
"B" Logic	P.C. Board A27	1 MC Precision Oscillator	P.C. Board A38
Control	P.C. Board A28	Attenuator Switch	A39, A40*

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
A1	887-411654	Model 860 DCU Refer to appended manual	2
A2	887-412638	Data Storage Unit Refer to appended manual	7
A3	887-411653	Model 850 DCU Refer to appended manual	12
A4		Same as A2	
A5		Same as A3	
A6		Same as A2	
A7		Same as A3	
A8		Same as A2	
A9		Same as A3	
A10		Same as A2	
A11		Same as A3	
A12		Same as A2	
A13		Same as A3	
A14		Same as A2	
		* * *	
A17	887-410929	2.5 MC Input Amplifier	2
A17C1	637-824028	Capacitor, F. Mica, 1000 pf, 300V, 5%	1
A17C2	633-804717	Capacitor, F. Cerm, 0.01 μf, 500V	11
A17C3		Same as A17C2	
A17C4	631-824631	Capacitor, F. Elect, 10 μf, 20V, 20%	2
A17C5		Same as A17C4	
A17C6 thru A17C14		Same as A17C2	
A17CR1	755-819903	Diode, Zener, Silicon, 7V	1
A17L1	795-819899	Inductor, Fixed, R.F., 0.22 μH	1
A17L2	795-819898	Inductor, Fixed, R.F., 0.47 μH	2
A17L3		Same as A17L2	
A17L4	795-807878	Inductor, Fixed, R.F., 0.010 mH	1
A17Q1	755-409895	Transistor, Special	2
A17Q2	755-817964	Transistor, Silicon, NPN, 600 mw Max.	1
A17Q3		Same as A17Q1	
A17Q4	755-817587	Transistor, Germanium, PNP, 150 mw, Max.	1
A17Q5	755-819908	Transistor, Silicon, NPN, 300 mw	2
A17Q6		Same as A17Q5	
A17Q7	755-817811	Transistor, Germanium, PNP, 150 mw	2
A17Q8		Same as A17Q7	
A17R1	601-015449	Resistor, F. Comp, 1.8K, 1/2W, 5%	1
A17R2	601-000897	Resistor, F. Comp, 2.2K, 1/2W, 5%	2
A17R3	601-822297	Resistor, F. Comp, 4.7K, 1/4W, 5%	2
A17R4	601-823389	Resistor, F. Comp, 68Ω, 1/4W, 5%	5
A17R5		Same as A17R3	
A17R6	601-010942	Resistor, F. Comp, 6.8K, 1/2W, 5%	1
A17R7		Same as A17R4	
A17R8	601-822798	Resistor, F. Comp, 68K, 1/4W, 5%	2
A17R9		Same as A17R8	
A17R10	601-823904	Resistor, F. Comp, 100K, 1/4W, 5%	1
A17R11	601-823905	Resistor, F. Comp, 120K, 1/4W, 5%	1
A17R12	601-822296	Resistor, F. Comp, 3.3K, 1/4W, 5%	1
A17R13	601-822527	Resistor, F. Comp, 1.5K, 1/4W, 5%	2
A17R14		Same as A17R2	
A17R15		Same as A17R4	
A17R16	601-822397	Resistor, F. Comp, 5.6K, 1/4W, 5%	1
A17R17		Same as A17R4	
A17R18	601-823379	Resistor, F. Comp, 10Ω, 1/4W, 5%	2
A17R19	601-822327	Resistor, F. Comp, 220Ω, 1/4W, 5%	2
A17R20		Same as A17R13	
A17R21		Same as A17R4	
A17R22	601-823390	Resistor, F. Comp, 120Ω, 1/4W, 5%	1
A17R23		Same as A17R18	
A17R24		Same as A17R19	
A17R25	601-823395	Resistor, F. Comp, 470Ω, 1/4W, 5%	1
A17R26	601-024744	Resistor, F. Comp, 180Ω, 1/2W, 5%	2
A17R27	607-824997	Resistor, F. Film, 249Ω, 1/2W, 1%	1
A17R28		Same As A17R26	
A17R29	607-824996	Resistor, F. Film, 267Ω, 1/2W, 1%	1
A17R30	607-824998	Resistor, F. Film, 178Ω, 1/4W, 1%	1
	776-827315	Heat Sink	2
	864-412958	Pad, Converter, Transistor	8

*Not contained in Model 6124

Detail No.	Beckman Stock No.	Description	Qty. Ass'y
A18		Same as A17	
A19 thru A24		Same as A3	
A25		Same as A1	
		* * *	
A26	887-412126	"F" Logic	1
A26C1	633-804717	Capacitor, F. Cerm, 0.01 μf, 500V	9
A26C2	637-824011	Capacitor, F. Mica, 39 pf, 300V, 5%	2
A26C3		Same as A26C2	
A26C4	637-824010	Capacitor, F. Mica, 33 pf, 300V, 5%	3
A26C5	637-824008	Capacitor, F. Mica, 22 pf, 300V, 5%	1
A26C6		Same as A26C4	
A26C7	637-824012	Capacitor, F. Mica, 47 pf, 300V, 5%	1
A26C8		Same as A26C4	
A26C9 thru A26C16		Same as A26C1	
A26CR1 thru A26CR7	755-815561	Diode, Silicon, 75 PIV, 10 ma, 1V, Min. Fwd.	12
A26CR8	755-402107	Diode, Special	1
A26CR9 thru A26CR13		Same as A26CR1	
A26CR14	755-817812	Diode, Ger., 15 PIV, 100 ma, 1V, Min. Fwd.	1
A26R1 thru A26R8	601-823107	Resistor, F. Comp, 15K, 1/4W, 10%	8
A26R9 thru A26R12	601-823112	Resistor, F. Comp, 1.5K, 1/4W, 10%	4
A26R13	601-823923	Resistor, F. Comp, 33Ω, 1/4W, 10%	2
A26R14		Same as A26R13	
		* * *	
A27	887-412559	"B" Logic	1
A27C1 thru A27C3	637-824011	Capacitor, F. Mica, 39 pf, 300V, 5%	4
A27C4	637-824014	Capacitor, F. Mica, 68 pf, 300V, 5%	1
A27C5		Same as A27C1	
A27C6	637-824010	Capacitor, F. Mica, 33 pf, 300V, 5%	1
A27C7 thru A27C13	633-804717	Capacitor, F. Cerm, 0.01 μf, 500V	7
A27CR1 thru A27CR12	755-815561	Diode, Silicon, 75 PIV, 10 ma, 1V, Min. Fwd.	12
A27R1 thru A27R6	601-823107	Resistor, F. Comp, 15K, 1/4W, 10%	6
A27R7	601-823923	Resistor, F. Comp, 33Ω, 1/4W, 10%	1
		* * *	
A28	887-410903	Control Board	1
A28C1	633-804717	Capacitor, F. Cerm, 0.01 μf, 500V	4
A28C2	637-824016	Capacitor, F. Mica, 100 pf, 300V, 5%	1
A28C3	637-824008	Capacitor, F. Mica, 22 pf, 300V, 5%	4
A28C4		Same as A28C1	
A28C5		Same as A28C3	
A28C6		Same as A28C1	
A28C7	637-824012	Capacitor, F. Mica, 47 pf, 300V, 5%	1
A28C8		Same as A28C3	
A28C9		Same as A28C3	
A28C10		Same as A28C1	
A28CR1 thru A28CR5	755-815561	Diode, Silicon, 75 PIV, 10 ma, 1V, Min. Fwd.	7
A28CR6	755-824300	Diode, Germanium, Type HD1842	4
A28CR7		Same as A28CR6	
A28CR8		Same as A28CR1	
A28CR9		Same as A28CR1	
A28CR10		Same as A28CR6	
A28CR11		Same as A28CR6	
A28Q1	755-817811	Transistor, Germanium, PNP, 150 mw	8
A28Q2		Same as A28Q1	
A28Q3	755-819908	Transistor, Silicon, NPN, 300 mw	1
A28Q4 thru A28Q9		Same as A28Q1	
A28R1	601-008068	Resistor, F. Comp, 180Ω, 1/2W, 10%	3
A28R2		Same as A28R1	
A28R3	601-823921	Resistor, F. Comp, 22Ω, 1/4W, 10%	1
A28R4	601-823395	Resistor, F. Comp, 470Ω, 1/4W, 5%	1
A28R5	601-823944	Resistor, F. Comp, 5.6K, 1/4W, 10%	2
A28R6		Same as A28R1	
A28R7	601-823108	Resistor, F. Comp, 10K, 1/4W, 10%	2
A28R8	601-823945	Resistor, F. Comp, 6.8K, 1/4W, 10%	3
A28R9	601-823946	Resistor, F. Comp, 8.2K, 1/4W, 10%	2
A28R10	601-823107	Resistor, F. Comp, 15K, 1/4W, 10%	6
A28R11		Same as A28R9	
A28R12	601-823111	Resistor, F. Comp, 1K, 1/4W, 10%	5
A28R13	601-823112	Resistor, F. Comp, 1.5K, 1/4W, 10%	1
A28R14		Same as A28R8	
A28R15		Same as A28R10	
A28R16	601-822397	Resistor, F. Comp, 5.6K, 1/4W, 5%	4
A28R17		Same as A28R12	
A28R18		Same as A28R16	
A28R19		Same as A28R10	
A28R20	601-823934	Resistor, F. Comp, 270Ω, 1/4W, 10%	2
A28R21		Same as A28R12	
A28R22		Same as A28R7	
A28R23		Same as A28R5	
A28R24		Same as A28R16	
A28R25		Same as A28R10	
A28R26		Same as A28R12	
A28R27		Same as A28R16	
A28R28		Same as A28R10	
A28R29		Same as A28R20	
A28R30		Same as A28R12	
A28R31		Same as A28R8	
A28R32		Same as A28R10	
	864-412958	Pad, Connector, Transistor	8
		* * *	
A29	887-411842	"M" Logic	1
A29C1	633-804717	Capacitor, F. Cerm, 0.01 μf, 500V	2
A29C2		Same as A29C1	
A29C3 thru A29C8	637-824022	Capacitor, F. Mica, 330 pf, 300V, 5%	12

Detail No.	Beckman Stock No.	Description	Qty. / Ass'y
A29C9	637-824016	Capacitor, F. Mica, 100 pf, 300V, 5%	1
A29C10	637-824018	Capacitor, F. Mica, 150 pf, 300V, 5%	1
A29C11	637-824020	Capacitor, F. Mica, 220 pf, 300V, 5%	1
A29C12	637-824024	Capacitor, F. Mica, 470 pf, 300V, 5%	1
A29C13 thru A29C18		Same as A29C3	
A29CR1	755-402107	Diode, Special	14
A29CR2	755-404593	Diode, Special	7
A29CR3 thru A29CR9		Same as A29CR1	
A29CR10	755-824300	Diode, Germanium, Type HD1842	1
A29CR11 thru A29CR16		Same as A29CR1	
A29CR17 thru A29CR22		Same as A29CR2	
A29Q1	755-817811	Transistor, Germanium, PNP, 150 mw	2
A29Q2		Same as A29Q1	
A29Q3	755-800398	Transistor, Germanium, PNP, 150 mw Max.	1
A29Q4	755-817587	Transistor, Germanium, PNP, 150 mw	2
A29Q5		Same as A29Q4	
A29R1	601-823107	Resistor, F. Comp, 15K, 1/4W, 10%	13
A29R2	601-823944	Resistor, F. Comp, 5.6K, 1/4W, 10%	2
A29R3	601-823937	Resistor, F. Comp, 680Ω, 1/4W, 10%	3
A29R4 thru A29R9		Same as A29R1	
A29R10		Same as A29R3	
A29R11		Same as A29R3	
A29R12 thru A29R16	601-815239	Resistor, F. Comp, 4.7K, 1/4W, 10%	5
A29R17	601-823939	Resistor, F. Comp, 1.2K, 1/4W, 10%	1
A29R18	601-822527	Resistor, F. Comp, 1.5K, 1/4W, 5%	1
A29R19	601-823931	Resistor, F. Comp, 150Ω, 1/4W, 10%	1
A29R20		Same as A29R2	
A29R21	601-812856	Resistor, F. Comp, 2.2K, 1/4W, 10%	1
A29R22	601-823925	Resistor, F. Comp, 47Ω, 1/4W, 10%	1
A29R23	601-823108	Resistor, F. Comp, 10K, 1/4W, 10%	1
A29R24	601-823112	Resistor, F. Comp, 1.5K, 1/4W, 10%	3
A29R25		Same as A29R24	
A29R26	601-822324	Resistor, F. Comp, 10K, 1/4W, 5%	1
A29R27	601-822333	Resistor, F. Comp, 12K, 1/4W, 5%	1
A29R28		Same as A29R24	
A29R29	601-823110	Resistor, F. Comp, 22K, 1/4W, 10%	1
A29R30 thru A29R35		Same as A29R1	
	864-412958	Pad, Connector, Transistor	5
		* * *	
A30	887-411674	Time Base Logic	1
A30C1	633-804717	Capacitor, F. Cerm, 0.01 μf, 500V	2
A30C2	637-824018	Capacitor, F. Mica, 150 pf, 300V, 5%	6
A30C3	637-824020	Capacitor, F. Mica, 220 pf, 300V, 5%	1
A30C4 thru A30C6		Same as A30C2	
A30C7		Same as A30C1	
A30C8		Same as A30C2	
A30C9		Same as A30C2	

Detail No.	Beckman Stock No.	Description	Qty. / Ass'y
A30C10	637-824012	Capacitor, F. Mica, 47 pf, 300V, 5%	2
A30C11		Same as A30C10	
A30C12	637-824011	Capacitor, F. Mica, 39 pf, 300V, 5%	1
A30CR1	755-402107	Diode, Special	8
A30CR2		Same as A30CR1	
A30CR3	755-824300	Diode, Germanium, Type HD1842	2
A30CR4		Same as A30CR1	
A30CR5		Same as A30CR1	
A30CR6		Same as A30CR3	
A30CR7 thru A30CR10		Same as A30CR1	
A30CR11	755-815561	Diode, Silicon, 75 PIV, 10 ma, 1V, Min. Fwd.	1
A30Q1	755-817811	Transistor, Germanium, PNP, 150 mw	2
A30Q2		Same as A30Q1	
A30Q3	755-800398	Transistor, Germanium, PNP, 150 mw, Max.	1
A30R1	601-823107	Resistor, F. Comp, 15K, 1/4W, 10%	8
A30R2	601-815239	Resistor, F. Comp, 4.7K, 1/4W, 10%	8
A30R3	601-823104	Resistor, F. Comp, 390Ω, 1/4W, 10%	1
A30R4	601-822296	Resistor, F. Comp, 3.3K, 1/4W, 5%	1
A30R5		Same as A30R1	
A30R6		Same as A30R2	
A30R7	601-822299	Resistor, F. Comp, 6.8K, 1/4W, 5%	1
A30R8		Same as A30R2	
A30R9	601-823937	Resistor, F. Comp, 680Ω, 1/4W, 10%	2
A30R10		Same as A30R1	
A30R11		Same as A30R2	
A30R12		Same as A30R1	
A30R13		Same as A30R9	
A30R14	601-823942	Resistor, F. Comp, 3.3K, 1/4W, 10%	2
A30R15		Same as A30R1	
A30R16		Same as A30R2	
A30R17		Same as A30R1	
A30R18		Same as A30R2	
A30R19		Same as A30R1	
A30R20		Same as A30R2	
A30R21		Same as A30R1	
A30R22	601-823951	Resistor, F. Comp, 47K, 1/4W, 10%	1
A30R23		Same as A30R2	
A30R24	601-823112	Resistor, F. Comp, 1.5K, 1/4W, 10%	2
A30R25		Same as A30R24	
A30R26		Same as A30R14	
	864-412958	Pad, Converter, Transistor	3
		* * *	
A32	887-411672	Legend Board	1
A32C1	633-804717	Capacitor, F Cerm, 0.01 μf, 500V, -20 + 80%	4
A32C2	637-824020	Capacitor, F. Mica, 220 pf, 300V, 5%	2
A32C3	631-814053	Capacitor, F. Elect, 1 μf, 35V, 20%	1
A32C4		Same as A32C2	
A32C5 thru A32C7		Same as A32C1	
A32CR1 thru A32CR4	755-815561	Diode, Silicon, 75 PIV, 10 ma, 1V, Min. Fwd.	4
A32CR5	755-404593	Diode, Special	1
A32DS1 thru A32DS6	825-414955	Lamp, Neon	6

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
A32Q1	755-800398	Transistor, Germanium, PNP, 150 mw Max.	2
A32Q2		Same as A32Q1	
A32Q3	755-410066	Transistor, Special	1
A32Q4	755-817964	Transistor, Silicon, NPN, 600 mw Max.	1
A32R1 thru A32R6	601-822337	Resistor, F. Comp, 91K, 1/4W, 5%	6
A32R7	601-824112	Resistor, F. Comp, 2.7M, 1/4W, 10%	4
A32R8		Same as A32R7	
A32R9	601-824831	Resistor, F. Comp, 2.2M, 1/4W, 10%	1
A32R10		Same as A32R7	
A32R11		Same as A32R7	
A32R12	601-824832	Resistor, F. Comp, 1.5M, 1/4W, 10%	1
A32R13 thru A32R18	601-823951	Resistor, F. Comp, 47K, 1/4W, 10%	6
A32R19	601-823112	Resistor, F. Comp, 1.5K, 1/4W, 10%	2
A32R20	601-822334	Resistor, F. Comp, 22K, 1/4W, 5%	1
A32R21		Same as A32R19	
A32R22	601-822324	Resistor, F. Comp, 10K, 1/4W, 5%	1
A32R23	601-823107	Resistor, F. Comp, 15K, 1/4W, 10%	1
A32R24	601-823954	Resistor, F. Comp, 82K, 1/4W, 10%	1
A32R25	601-823110	Resistor, F. Comp, 22K, 1/4W, 10%	1
A32R26	601-823109	Resistor, F. Comp, 33K, 1/4W, 10%	1
A32R27	601-815239	Resistor, F. Comp, 4.7K, 1/4W, 10%	2
A32R28	601-823945	Resistor, F. Comp, 6.8K, 1/4W, 10%	2
A32R29	601-823948	Resistor, F. Comp, 18K, 1/4W, 10%	1
A32R30		Same as A32R27	
A32R31		Same as A32R28	
A32V1 thru A32V6	753-416278	Photo-Resistor, End-View, Special	6
	824-414475	Lamp Block, Cover	1
	824-412922	Lamp Block, Base	1
	864-412958	Pad, Converter, Transistor	4
		* * *	
A33	887-411673	Recycle	1
A33C1	637-824020	Capacitor, F. Mica, 220 pf, 300V, 5%	17
A33C2	637-824024	Capacitor, F. Mica, 470 pf, 300V, 5%	4
A33C3		Same as A33C2	
A33C4		Same as A33C1	
A33C5		Same as A33C1	
A33C6	637-824022	Capacitor, F. Mica, 330 pf, 300V, 5%	1
A33C7		Same as A33C1	
A33C8		Same as A33C1	
A33C9		Same as A33C2	
A33C10	631-819463	Capacitor, F. Elect, 3.3 μf, 15V, 10%	1
A33C11	637-824018	Capacitor, F. Mica, 150 pf, 300V, 5%	2
A33C12		Same as A33C1	
A33C13		Same as A33C1	
A33C14	637-824027	Capacitor, F. Mica, 820 pf, 300V, 5%	1
A33C15		Same as A33C2	
A33C16		Same as A33C1	
A33C17	631-828102	Capacitor, F. Elect, 4.7 μf, 100V, -15% +20%	1
A33C18	633-804717	Capacitor, F. Cerm, 0.01 μf, 500V	3
A33C19 thru A33C23		Same as A33C1	
A33C24		Same as A33C18	
A33C25		Same as A33C1	
A33C26		Same as A33C11	
A33C27		Same as A33C1	
A33C28		Same as A33C18	
A33C29		Same as A33C1	
A33C30	631-814053	Capacitor, F. Elect, 1 μf, 35V, 20%	1
A33C31		Same as A33C1	
A33C32	637-824028	Capacitor, F. Mica, 1000 pf, 300V, 5%	1
A33CR1 thru A33CR5	755-404593	Diode, Special	27
A33CR6	755-402107	Diode, Special	3
A33CR7 thru A33CR13		Same as A33CR1	
A33CR14		Same as A33CR6	
A33CR15 thru A33CR21		Same as A33CR1	
A33CR22		Same as A33CR6	
A33CR23 thru A33CR30		Same as A33CR1	
A33DS1	825-414955	Lamp, Neon, Special	1
A33Q1 thru A33Q12	755-800398	Transistor, Germanium, PNP, 150 mw, Max.	23
A33Q13	755-410066	Transistor, Special	1
A33Q14 thru A33Q24		Same as A33Q1	
A33R1	601-823949	Resistor, F. Comp, 27K, 1/4W, 10%	1
A33R2	601-823942	Resistor, F. Comp, 3.3K, 1/4W, 10%	10
A33R3	601-823948	Resistor, F. Comp, 18K, 1/4W, 10%	2
A33R4	601-823944	Resistor, F. Comp, 5.6K, 1/4W, 10%	2
A33R5	601-823109	Resistor, F. Comp, 33K, 1/4W, 10%	7
A33R6	601-823108	Resistor, F. Comp, 10K, 1/4W, 10%	13
A33R7		Same as A33R2	
A33R8	601-822334	Resistor, F. Comp, 22K, 1/4W, 5%	6
A33R9	601-823933	Resistor, F. Comp, 220Ω, 1/4W, 10%	2
A33R10	601-823107	Resistor, F. Comp, 15K, 1/4W, 10%	3
A33R11	601-823951	Resistor, F. Comp, 47K, 1/4W, 10%	2
A33R12		Same as A33R2	
A33R13 thru A33R15		Same as A33R6	
A33R16	601-823110	Resistor, F. Comp, 22K, 1/4W, 10%	8
A33R17	601-822324	Resistor, F. Comp, 10K, 1/4W, 5%	5
A33R18	601-823112	Resistor, F. Comp, 1.5K, 1/4W, 10%	13
A33R19		Same as A33R8	
A33R20		Same as A33R18	
A33R21	601-823931	Resistor, F. Comp, 150Ω, 1/4W, 10%	2
A33R22		Same as A33R18	
A33R23		Same as A33R6	
A33R24		Same as A33R17	
A33R25		Same as A33R16	
A33R26		Same as A33R18	
A33R27		Same as A33R8	
A33R28		Same as A33R18	
A33R29		Same as A33R5	
A33R30		Same as A33R10	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
A33R31		Same as A33R5	
A33R32		Same as A33R2	
A33R33		Same as A33R17	
A33R34		Same as A33R16	
A33R35		Same as A33R18	
A33R36		Same as A33R8	
A33R37		Same as A33R6	
A33R38		Same as A33R18	
A33R39	601-823923	Resistor, F. Comp, 33Ω, 1/4W, 10%	1
A33R40		Same as A33R18	
A33R41		Same as A33R3	
A33R42		Same as A33R4	
A33R43		Same as A33R5	
A33R44		Same as A33R2	
A33R45		Same as A33R8	
A33R46		Same as A33R9	
A33R47		Same as A33R11	
A33R48		Same as A33R2	
A33R49		Same as A33R2	
A33R50		Same as A33R6	
A33R51	601-823945	Resistor, F. Comp, 6.8K, 1/4W, 10%	2
A33R52		Same as A33R16	
A33R53	601-815239	Resistor, F. Comp, 4.7K, 1/4W, 10%	1
A33R54	601-812856	Resistor, F. Comp, 2.2K, 1/4W, 10%	1
A33R55	601-823944	Resistor, F. Comp, 5.6K, 1/4W, 5%	1
A33R56	601-043210	Resistor, F. Comp, 12K, 1W, 5%	1
A33R57		Same as A33R5	
A33R58		Same as A33R5	
A33R59	601-823947	Resistor, F. Comp, 12K, 1/4W, 10%	1
A33R60		Same as A33R2	
A33R61		Same as A33R6	
A33R62	601-822333	Resistor, F. Comp, 12K, 1/4W, 5%	1
A33R63		Same as A33R5	
A33R64		Same as A33R2	
A33R65 thru A33R67		Same as A33R6	
A33R68		Same as A33R17	
A33R69		Same as A33R16	
A33R70		Same as A33R18	
A33R71		Same as A33R8	
A33R72		Same as A33R18	
A33R73		Same as A33R21	
A33R74		Same as A33R18	
A33R75		Same as A33R16	
A33R76		Same as A33R17	
A33R77		Same as A33R18	
A33R78		Same as A33R16	
A33R79	601-823929	Resistor, F. Comp, 100Ω, 1/4W, 10%	2
A33R80		Same as A33R18	
A33R81		Same as A33R6	
A33R82	601-812742	Resistor, F. Comp, 220K, 1/4W, 10%	1
A33R83		Same as A33R79	
A33R84		Same as A33R6	
A33R85		Same as A33R2	
A33R86		Same as A33R51	
A33R87		Same as A33R16	
A33R88		Same as A33R10	
	864-412958	Pad, Converter, Transistor	24

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
A34	887-412442	Regulator	1
A34C1	631-814053	Capacitor, F. Elect, 1 μf, 35V, 20%	2
A34C2		Same as A34C1	
A34CR1	755-404593	Diode, Silicon, Special	2
A34CR2	755-824951	Diode, Zener, 400 mw	2
A34CR3		Same as A34CR1	
A34CR4		Same as A34CR2	
A34Q1	755-811274	Transistor, Type 2N445A	2
A34Q2	755-800398	Transistor, Germanium, PNP, 150 mw, Max.	4
A34Q3		Same as A34Q2	
A34Q4		Same as A34Q1	
A34Q5		Same as A34Q2	
A34Q6		Same as A34Q2	
A34Q7	755-415078	Transistor, Special	1
A34R1	601-823934	Resistor, F. Comp, 270Ω, 1/4W, 10%	2
A34R2	601-008065	Resistor, F. Comp, 100Ω, 1/2W, 10%	1
A34R3	601-823104	Resistor, F. Comp, 390Ω, 1/4W, 10%	2
A34R4	601-823105	Resistor, F. Comp, 470Ω, 1/4W, 10%	2
A34R5	601-823112	Resistor, F. Comp, 1.5K, 1/4W, 10%	1
A34R6	601-008059	Resistor, F. Comp, 2.2K, 1W, 10%	2
A34R7	601-815239	Resistor, F. Comp, 4.7K, 1/4W, 10%	2
A34R8	611-812861	Resistor, V., WW, 200Ω, 1-1/2W, 20%	2
A34R9	601-008071	Resistor, F. Comp, 330Ω, 1/2W, 10%	2
A34R10		Same as A34R1	
A34R11	601-008068	Resistor, F. Comp, 180Ω, 1/2W, 10%	1
A34R12		Same as A34R4	
A34R13		Same as A34R3	
A34R14		Same as A34R8	
A34R15		Same as A34R6	
A34R16		Same as A34R7	
A34R17		Same as A34R9	
A34R18	601-812856	Resistor, F. Comp, 2.2K, 1/4W, 10%	1
A34R19	601-800143	Resistor, Fixed Comp, 3.3K, 2W, 5%	1
A34R20	601-822296	Resistor, Fixed Comp, 3.3K, 1/4W, 5%	1
A34R21	611-812860	Resistor, Variable, WW, 2000Ω, 1.50W, 20%	1
A34R22	601-016229	Resistor, Fixed Comp, 1.5K, 1W, 5%	1
A34R23	601-800132	Resistor, Fixed Comp, 680Ω, 2W, 5%	1
A34R24	601-043215	Resistor, Fixed Comp, 18K, 1W, 5%	1
	864-412958	Pad, Converter, Transistor	6
		* * *	
A35	887-412795	E. L. Supply	1
A35C1	631-824631	Capacitor, F. Elect, 10 μf, 20V, 20%	1
A35C2	631-802980	Capacitor, F. Elect, 22 μf, 25V, 20%	1
A35C3	631-828130	Capacitor, F. Elect, 150 μf, 15V, 10%	1
A35Q1	755-824875	Transistor, Germanium, PNP, 63W	2
A35Q2		Same as A35Q1	
A35Q3	755-800398	Transistor, Germanium, PNP, 150 mw, Max.	2
A35Q4		Same as A35Q3	
A35R1	601-800031	Resistor, F. Comp, 470Ω, 1/2W, 10%	2
A35R2	601-823917	Resistor, F. Comp, 10Ω, 1/4W, 10%	1
A35R3		Same as A35R1	
A35R4	611-812861	Resistor, V., WW, 200Ω, 1-1/2W, 20%	1
A35R5	601-008071	Resistor, F. Comp, 330Ω, 1/2W, 10%	1
A35R6	601-008068	Resistor, F. Comp, 180Ω, 1/2W, 10%	1
A35R7	601-010684	Resistor, F. Comp, 3.3K, 1/2W, 10%	1

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
A35R8	601-007932	Resistor, F. Comp, 10K, 1/2W, 10%	1
A35R9	601-823935	Resistor, F. Comp, 330Ω, 1/4W, 10%	1
A35R10	604-819969	Resistor, F. WW, 1.5Ω, 1/2W, 5%	1
	864-412958	Pad, Transistor	2
		* * *	
A38	887-411676	1 MC Oscillator Assembly	1
C1	655-415515	Capacitor, V. Glass, 0.6-14 pf, 1000V, -40 to +50 PPM/°C	1
C2	633-	Capacitor, F. Cerm, 36 pf ±10%, 600V, Skottie NPO Type approx. (actual value to be selected at factory)	1
C3	633-827603	Capacitor, F. Cerm, 3.3 pf, T.C. -750 PPM/°C	1
L1	795-807919	Inductor, F., RF, 470 mH, 9Ω, 285 ma	2
L2		Same as L1	
XA43	680-824871	P.C. Connector, 15 Contacts	1
XY1	860-802333	Socket, Tube, 8 Pin Saddle Mounting	1
Y1	881-412796	Crystal and Oven Assembly	1
A38C1	631-814053	Capacitor, F. Elect, 1 μf, 35V, 20%	1
A38C2	631-802980	Capacitor, F. Elect, 22 μf, 25V, 20%	1
A38C3	633-804717	Capacitor, F. Cerm, 0.01 μf, 500V	2
A38C4		Same as A38C3	
A38C5	637-824018	Capacitor, F. Mica, 150 pf, 300V, 5%	1
A38C6	637-824302	Capacitor, F. Mica, 300 pf, 300V, 5%	1
A38C7	637-824028	Capacitor, F. Mica, 1000 pf, 300V, 5%	1
A38C8	637-824301	Capacitor, F. Mica, 2000 pf, 300V, 5%	2
A38C9	637-824025	Capacitor, F. Mica, 560 pf, 300V, 5%	2
A38C10		Same as A38C9	
A38C11		Same as A38C8	
A38C12	637-824303	Capacitor, F. Mica, 3900 pf, 300V, 5%	1
A38CR1	755-811280	Diode, Reference, Sil. 5.0 V Min, 5.5 V Max.	1
A38CR2	755-402107	Diode, Special	1
A38L1	795-807904	Inductor, Fixed, RF, 0.100 Millihenries	1
A38L2	795-827337	Inductor, Fixed, RF, 0.0068 Millihenries	1
A38Q1	755-817216	Transistor, Germanium, PNP, 75 mw Max.	2
A38Q2		Same as A38Q1	
A38Q3	755-817811	Transistor, Germanium, PNP, 150 mw	2
A38Q4		Same as A38Q3	
A38Q5	755-823113	Transistor, Silicon, NPN, 800 mw Max.	1
A38R1	601-822327	Resistor, F. Comp, 220Ω, 1/4W, 5%	1
A38R2	601-015446	Resistor, F. Comp, 470Ω, 1/2W, 5%	1
A38R3	601-822460	Resistor, F. Comp, 3.9K, 1/4W, 5%	2
A38R4	601-822299	Resistor, F. Comp, 6.8K, 1/4W, 5%	1
A38R5	601-822333	Resistor, F. Comp, 12K, 1/4W, 5%	1
A38R6	601-822306	Resistor, F. Comp, 820Ω, 1/4W, 5%	2
A38R7	601-822295	Resistor, F. Comp, 2.7K, 1/4W, 5%	2
A38R8		Same as A38R6	
A38R9		Same as A38R3	
A38R10	601-822308	Resistor, F. Comp, 1K, 1/4W, 5%	2
A38R11	611-812859	Resistor, V. WW, 5K, 1-1/2W, 20%	1
A38R12		Same as A38R7	
A38R13	601-822328	Resistor, F. Comp, 2.2K, 1/4W, 5%	1
A38R14		Same as A38R10	
A38R15	601-822544	Resistor, F. Comp, 1.8K, 1/4W, 5%	1
A38R16	601-817735	Resistor, F. Comp, 100Ω, 1/4W, 5%	1
A38R17	601-822326	Resistor, F. Comp, 1.2K, 1/4W, 5%	1
A38R18	601-822306	Resistor, F. Comp, 820Ω, 1/4W, 5%	2
A38R19		Same as A38R18	
	864-412958	Pad, Converter, Transistor	5
		* * *	
A39	855-416144	Attenuator Switch Assembly	2
A39C1	633-804722	Capacitor, F. Cerm, 0.02 μf, 600V	1
A39C2	633-804667	Capacitor, F. Cerm, 22 pf, 600V	1
A39C3	633-804657	Capacitor, F. Cerm, 5 pf, 600V	1
A39C4	637-824018	Capacitor, F. Mica, 150 pf, 300V, 5%	1
A39C5	637-824301	Capacitor, F. Mica, 2000 pf, 300V, 5%	1
A39R1	601-041151	Resistor, F. Comp, 1M, 1/2W, 5%	1
A39R2	601-008147	Resistor, F. Comp, 910K, 1/2W, 5%	1
A39R3	601-823904	Resistor, F. Comp, 100K, 1/4W, 5%	1
A39R4	601-013193	Resistor, F. Comp, 1.5M, 1/2W, 5%	1
A39R5	601-822324	Resistor, F. Comp, 10K, 1/4W, 5%	1
A39R6	601-015045	Resistor, F. Comp, 2.7K, 1/2W, 5%	2
A39R7	614-414678	Resistor, V. Comp, 2.5K, ±10%	
	010-415512	Attenuator Switch Spec. 7 Pos., 2 Sec.	
		* * *	
A40		Same as A39	
A41	711-413778	Reset, Recycle Rate Assembly	1
A42	887-413050	Plug-In, Model 696	1
A43	887-411676	1 MC Oscillator	1
		* * *	
B1	842-819209	Fan Motor	1
C1 thru C3	631-412828 (Pow. Sup.)	Capacitor, F. Elect, 1500 μf, 30V	3
C1	637-819111	Capacitor, F. Mica, 47 pf, 500V, 5%	1
C4	631-410854	Capacitor, F. Elect, 300 μf, 150V	1
C5	633-804717	Capacitor, F. Cerm, 0.01 μf, 500V -20 +80%	1
C6	633-804717	Capacitor, F. Cerm, 0.01 μf, 500V	1
C9	643-805005	Capacitor, V. Cerm, 5-25 pf, 350V	4
C10		Same as C9	
C12		Same as C9	
C13		Same as C9	
CR1	774-824971	Rectifier Bridge, 3 amps.	1
CR2	774-824972	Rectifier Bridge, 1.5 amps.	2
CR3		Same as CR2	
CR4	755-404593	Diode, Special	1
DS1	824-824973	Lamp, Neon, Plug-In Cartridge	1
DS2	823-412941	Readout, E. L., Eight Digit	1
E1	778-413840	Amplifier Shield	1
F1	731-801567	Fuse, Electrical, 1.5 Amp., 125V, Time Delay	1
J1	670-806738	Connector, Coaxial, Receptacle, BNC Type	4
J2		Same as J1	
J3		Same as J1	
J4		Same as J1	
J5	683-817991	Jack, Banana, Red Nylon	1
J6	672-824946	Connector, Receptacle, 50 Female Contacts	1
J7		Same as J6	

Detail No,	Beckman Stock No.	Description	Qty./ Ass'y
J9	672-806833	Connector, Receptacle, 40 Female Contacts	1
K1	718-827701	Relay, 12V, 4 Form C	1
Q1 thru Q3	755-822107	Transistor, Germanium, PNP, 2 ma, Max.	3
Q4	755-415078	Transistor, Special	1
R1	601-800018 (Pow. Sup.)	Resistor, F. Comp, 10Ω, 1/2W, 10%	1
R1	601-823393	Resistor, F. Comp, 270Ω, 1/4W, 5%	1
R2	604-801990	Resistor, F. WW, 10Ω, 5W, 10%	1
R3	601-822371	Resistor, F. Comp, 390Ω, 1/4W, 5%	1
R4	601-823923	Resistor, F. Comp, 33Ω, 1/4W, 10%	1
R5	601-823921	Resistor, F. Comp, 22Ω, 1/4W, 10%	1
R6	601-823109	Resistor, F. Comp, 33K, 1/4W, 10%	1
R7	601-823111	Resistor, F. Comp, 1K, 1/4W, 10%	1
R8	601-800132	Resistor, F. Comp, 680Ω, 2W, 5%	1
S1	711-412989	Switch Specification, 14 Pos. 4 Sec. Type 7141R	1
S2	711-413605	Switch Specification, 14 Pos. 7 Sec.	1
S3	701-806040	Switch, Toggle, DPDT, 3 Amp. at 250V ac	1
S4	701-806039	Switch, Toggle, SPDT, 1 Amp. at 250V ac	1
S5	711-413785	Switch, Rotary, Oak Type F	1
S6	716-827410	Switch, Slide, DPDT	1
T1	792-411294	Transformer, Power	1
T2	792-411415	Transformer, E.L.	1
XA1	680-824871	Connector, Printed Circuit, 15 Contacts	42
XA2A & XA2B		Same as XA1	
XA3		Same as XA1	
XA4A & XA4B		Same as XA1	
XA5		Same as XA1	
XA6A & XA6B		Same as XA1	
XA7		Same as XA1	
XA8A & XA8B		Same as XA1	
XA9		Same as XA1	
XA10A & XA10B		Same as XA1	
XA11		Same as XA1	
XA12A & XA12B		Same as XA1	
XA13		Same as XA1	
XA14A & XA14B		Same as XA1	
XA15		Same as XA1	
XA16A & XA16B		Same as XA1	
XA17 & XA18		Same as XA1	
XA19		Same as XA1	
XA20		Same as XA1	
XA21 thru XA25		Same as XA1	
XA26	680-824115	Connector, Printed Circuit, 30 Contacts	3
XA27		Same as XA1	
XA28		Same as XA1	
XA29		Same as XA26	
XA30		Same as XA26	
XA31		Same as XA1	
XA32A & XA32B		Same as XA1	
XA33A & XA33B		Same as XA1	
XA34		Same as XA1	
XA35		Same as XA1	
XDS1	824-824974	Socket, Lamp Cartridge Mounting	1
XDS2	697-412938	Socket, 8 Digit Electroluminescent Panel	1
XE1		Same as XA1	
XF1	735-007268	Fuseholder, 15 Amp. at 250V Breakdown	1
XK1	860-824956	Socket, Relay	1
Z1	771-416479	Filter, Interference	1
		* * *	
	132-824977	Clip, Retainer, Indicator Lamp	1
	664-812450	Cordset, Elect, Power, 3 Cond, Blk, 6 ft.	1
	325-413171	Knob, Round, Skirted	2
	317-413693	Hinge, Handle	2
	325-413174	Knob, Round, Skirted, Concentric Base	1
	325-415351	Knob, Power	1
	325-415350	Knob, Attenuator	2
	325-415335	Knob, Display	1
	330-413694	Handle, Cast	1
	783-807862	Ferrite Bead	2
	776-411321	Heat Sink	1
	776-827328	Heat Sink	1
	662-414822	Cable, Digital Recorder - J9	1
	662-414804	Cable, J7, Plug-In	1
	297-413615	Top Cover	1
	349-414969	Tilt Foot	1
	716-413516	Reset Button	1
	327-413153	Bracket, Plug-In	1
	778-412944	E. L. Shield	1
	778-416148	Shield, Safety	1
	778-416305	Shield, Attenuator	1
	302-413692	Spring, Handle	2
	297-413696	Bottom Dust Cover	1
	855-416150	Attenuator Shield Assembly	1

MODIFICATIONS
MODEL 6100 SERIES

MODIFICATION AA

This modification substitutes a medium-stability oscillator (3 parts in 10^7 per week) for the precision oscillator (2 parts in 10^8 per week) in 25 mc and 50 mc 6100 Series instruments. Refer to schematic diagram No. C411996.

Specifications for the medium-stability oscillator are as follows:

Frequency: 1 megacycle.

Stability: 3 parts in 10^7 per week with ±10% line variation and ±10 degrees C temperature variation.

MODIFICATION AB

In instruments with Modification AB, a high-stability oscillator (2 parts in 10^8 per week) replaces the medium-stability oscillator. This modification affects 2.5 mc 6100 Series instruments. Refer to schematic diagrams C412391 and C412392.

Specifications for the high-stability oscillator are as follows:

Frequency: 1 megacycle.

Stability:

Long Term: 2 parts in 10^8 per week average; 5 parts in 10^9 standard deviation.

Short Term: 3 parts in 10^9 per 24 hours average; 1 part in 10^9 standard deviation.

MODIFICATION AC

With Modification AC the high-stability oscillator is supplied with a Certificate of Stability. This certificate includes such information as serial number of the oscillator unit, date of certification, and standard to which the unit was certified.

Oscillator circuitry is identical to that used in Modification AB.

MODIFICATION AD

Instruments with Modification AD have a DPX-57 connector added to the rear panel for remote programming. With this modification external control is possible for the MODE, TIME, RECYCLE RATE, RESET, and SLOPE controls. Unit Logic for the AD Modification in 2.5 mc and 25 mc instruments (Models 6124, 6144, 6126, and 6146) is shown in schematic diagram No. D421974. Drawing No. C418543 shows the required switching.

Unit Logic for 50 mc instruments (Models 6127, 6147) is shown in Drawing No. D418542. Drawing No. C418543 shows the required switching.

A Model 6100 Series instrument can be programmed with either contact closures or transistor switching. However, if the instrument is used with a plug-in (other than Basic Plug-in) contact closures must be used. If transistor switching is desired, contact the factory.

MODIFICATION AE

This modification provides 20 inch-travel slides for rack mounting.

MODIFICATION AF

This modification permits the instrument to be used with a 400 cps power source rather than the standard 60 cps. Except for the replacement of the 60 cps fan motor with a 400 cps motor, there are no circuit changes.

MODIFICATION AG

With this modification, front panel connectors for INPUT's X and Y are paralleled with connectors on the rear panel. This modification applies to the basic instrument only, and it is not available on plug-in modules.

MODIFICATION AH

Instruments with this modification have a 222 volt primary instead of the standard 117 volt. Figure 1 shows the AH Modification.

The 222 volt transformer can be converted to 117 volt operation by rewiring as shown in Figure 2.

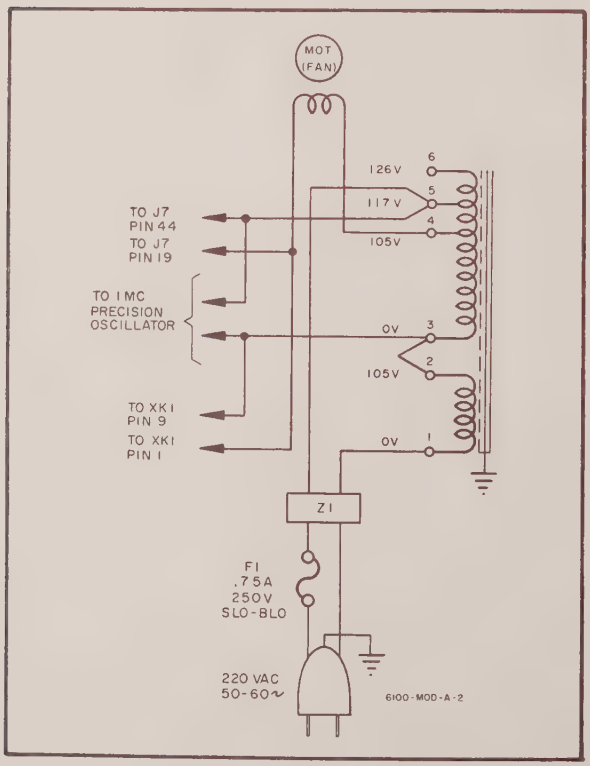


FIG. 1. 222 Volt Primary.

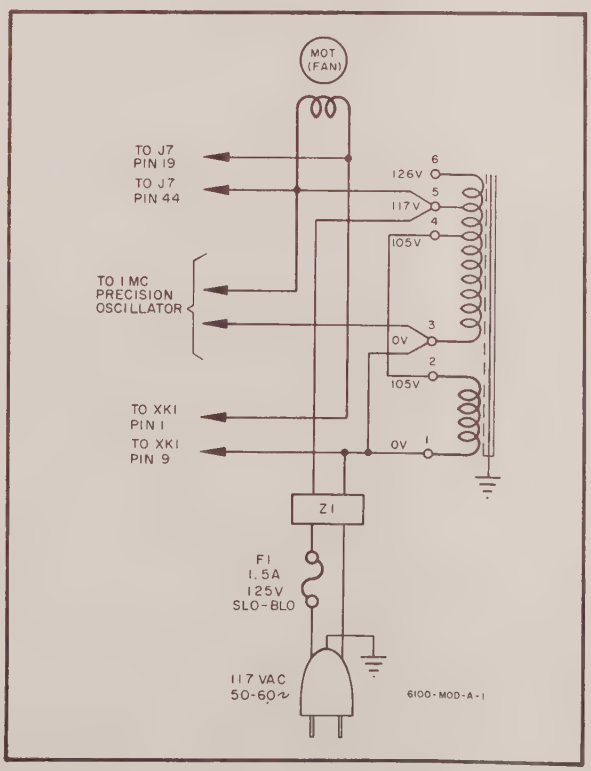
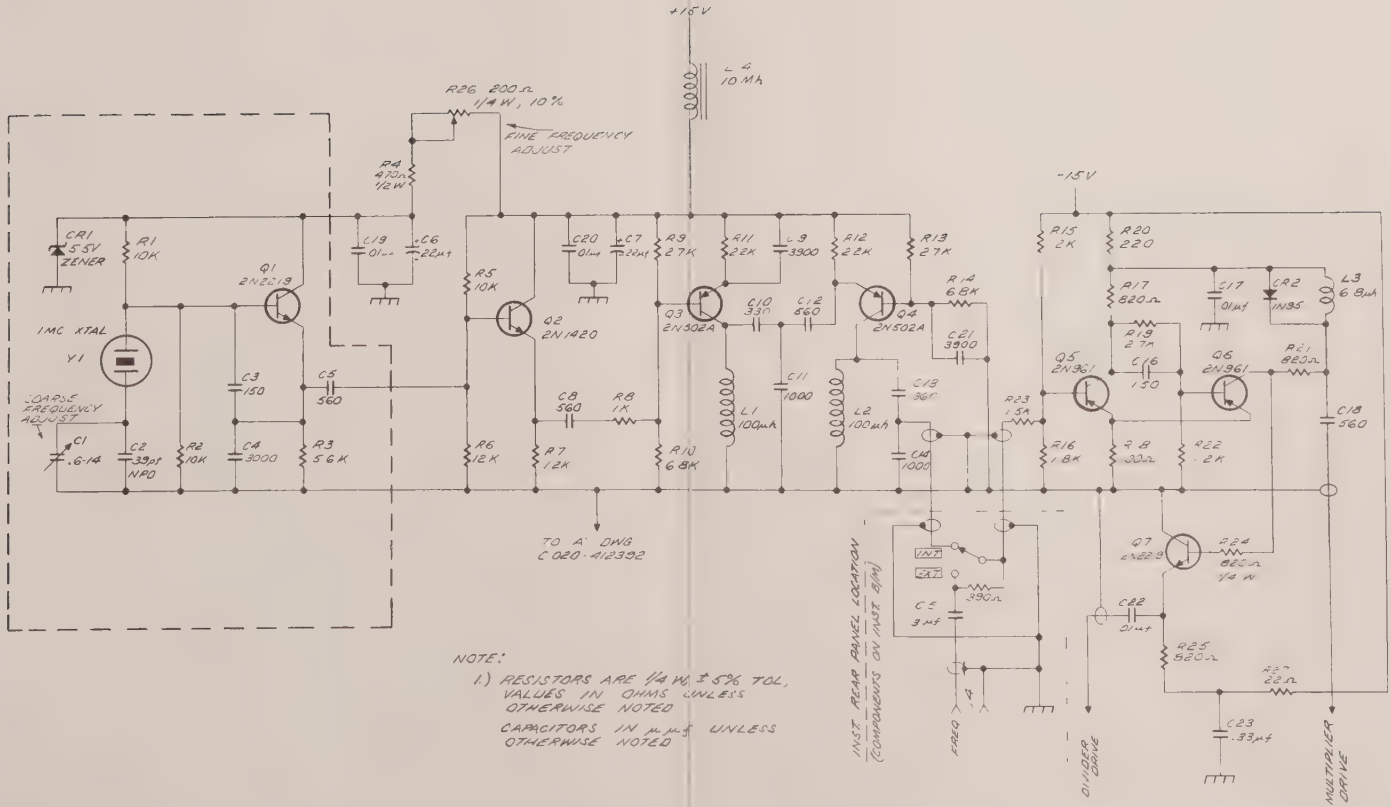


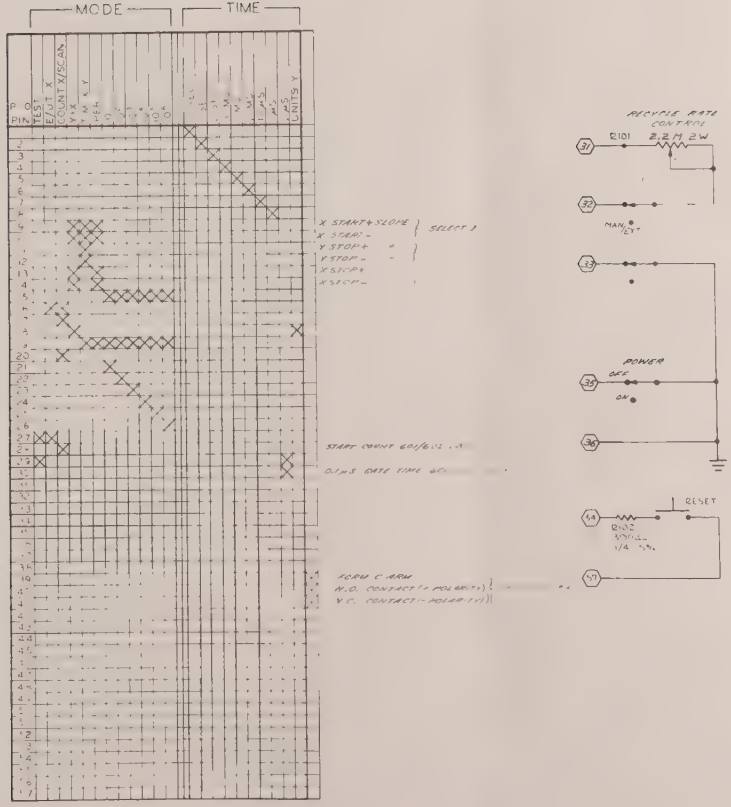
FIG. 2. 117 Volt Primary.

MOD. AB - 6100 SERIES
1 MC PRECISION OSCILLATOR
SCHEMATIC DIAGRAM



NOTE:
1.) RESISTORS ARE 1/4 W, ± 5% TOL, VALUES IN OHMS UNLESS OTHERWISE NOTED
CAPACITORS IN μμf UNLESS OTHERWISE NOTED

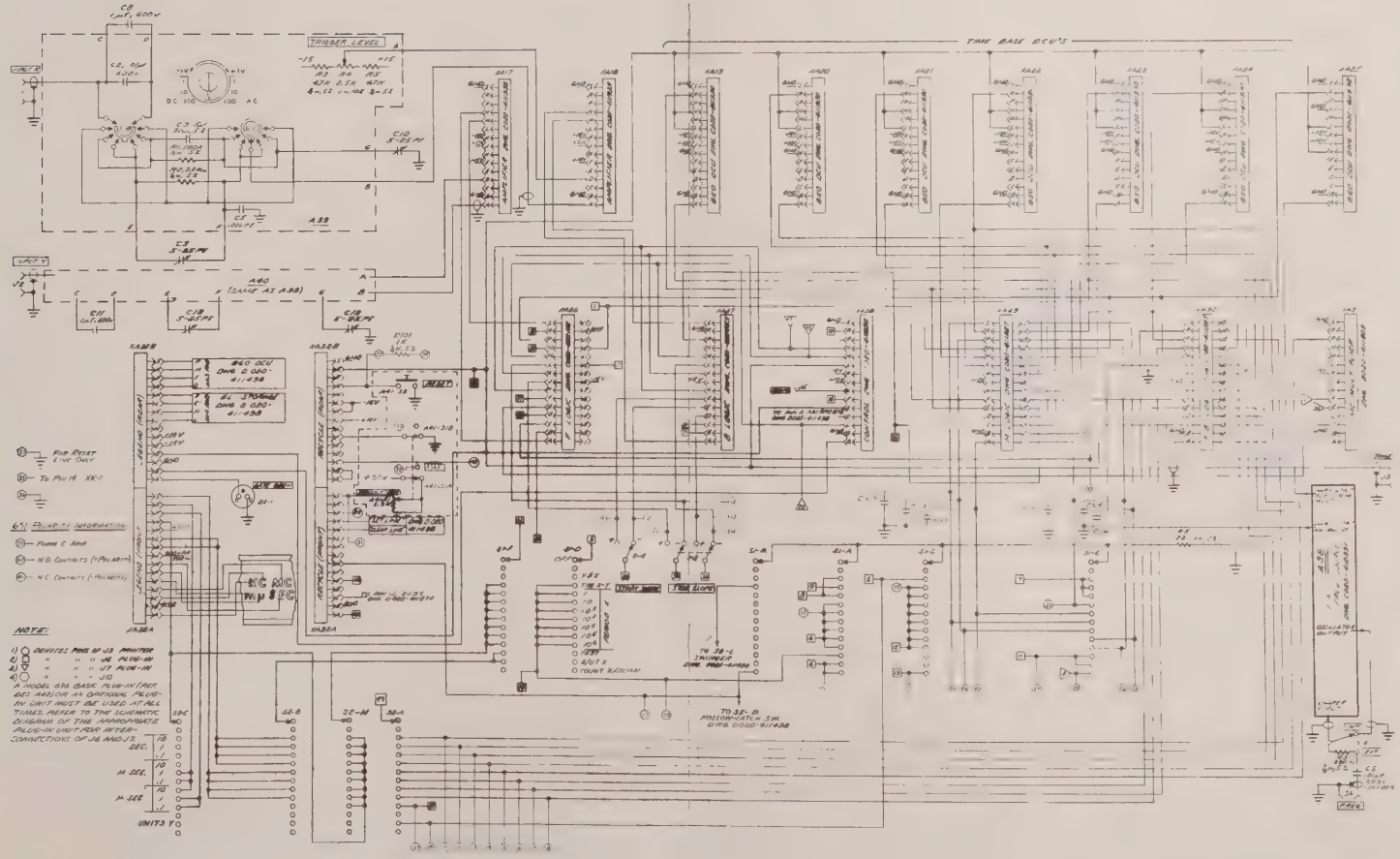
MOD. AD - 6100 SERIES
REMOTE PROGRAM MATRIX
SCHEMATIC DIAGRAM



NOTE

1. USE 1 μS ONLY IN TIME OF FREQ.
2. SEE INSTRUCTION MANUAL TABLE 2-2 FOR PROGRAM TABLE MATRIX COMBINATION.
3. TIE THIS PIN TO SIGNAL END (PIN 36) TO EXAMPLE IF LIGHT OF 1 MS TIME BASE ARE SELECTED GROUND PINS 3 LATCH.
4. IF A TRANSISTOR SWITCH IS USED FOR THE ABOVE IT MUST BE OPERATED IN THE SATURATED CONDITION TURNED ON (PNP).
5. THE + POLARITY INFORMATION IS AVAILABLE ONLY WHEN 65 PIN CARD IS EMPLOYED.

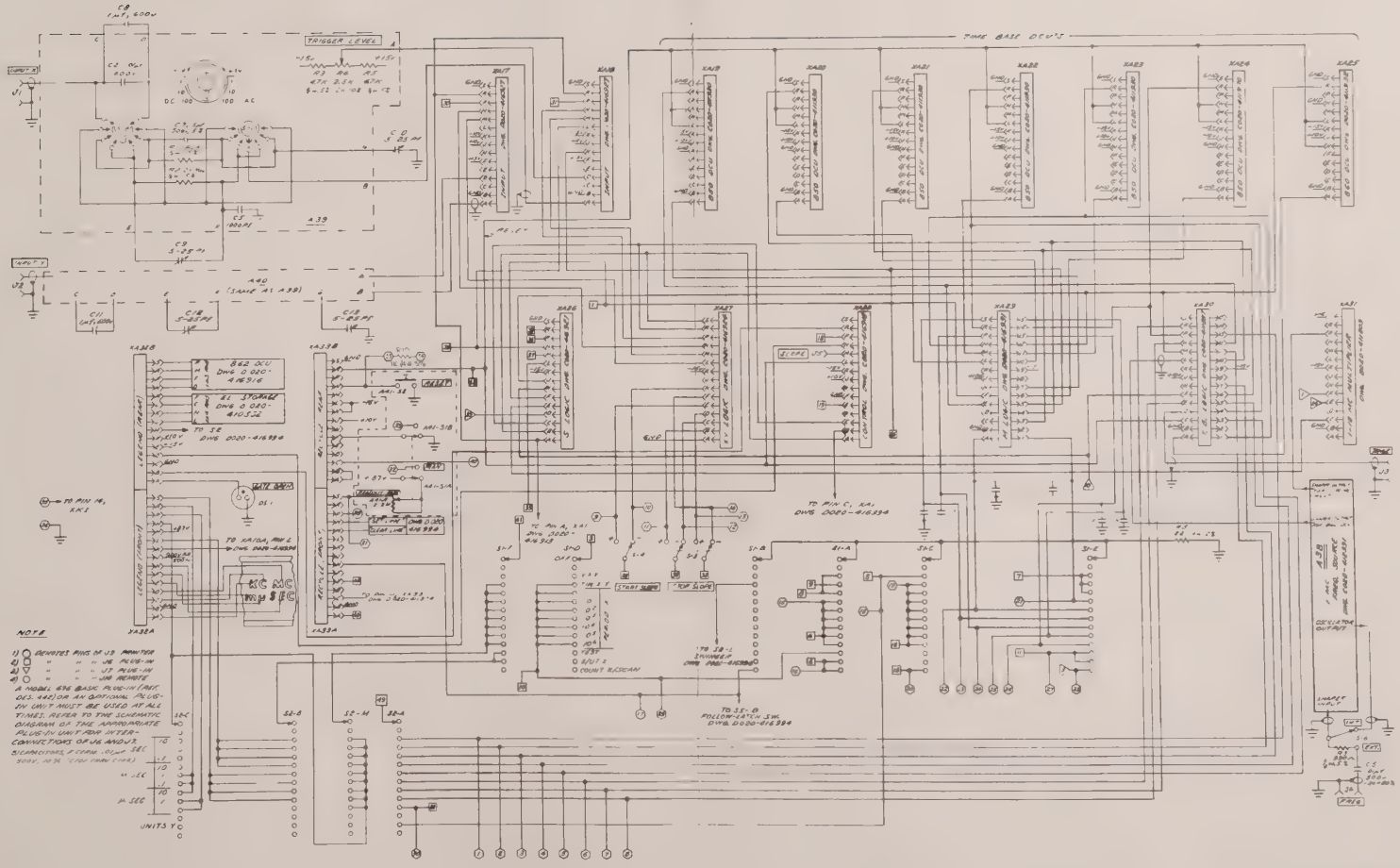
MOD. AD - 6100 SERIES
UNIT LOGIC - REMOTE
SCHEMATIC DIAGRAM



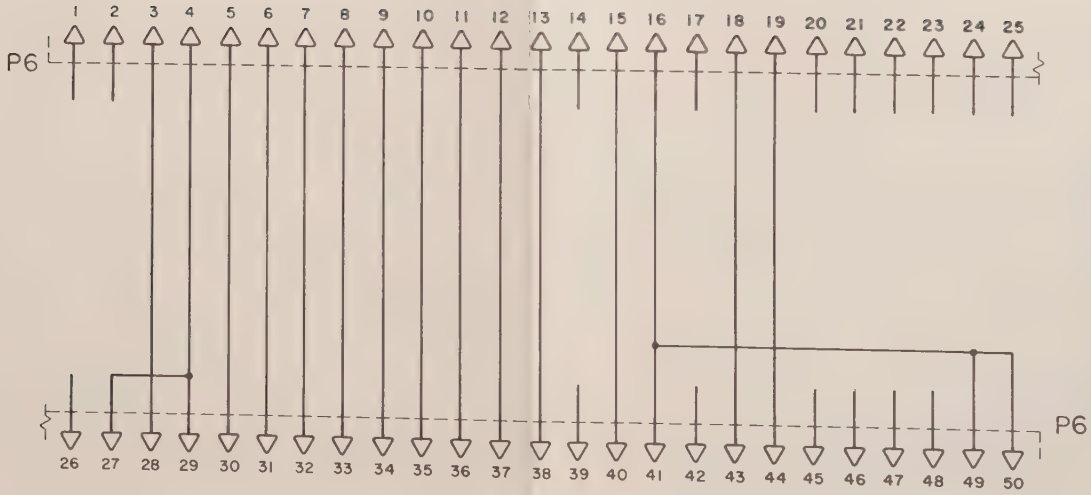
6145, 20, 6144 24
D 621874-Rev A
January 1965

Beckman®

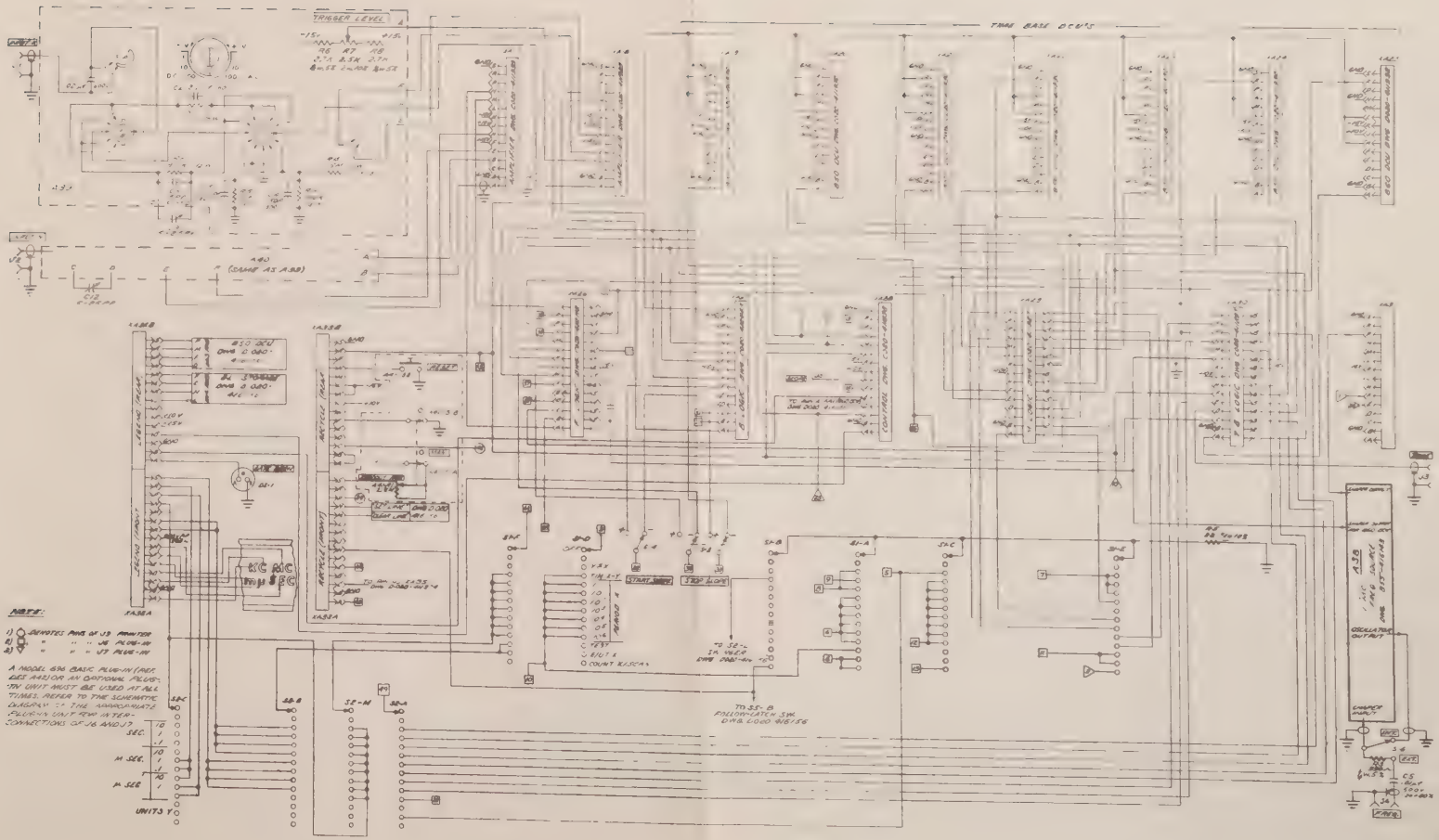
MOD. AD - MODELS 6127 & 6147
UNIT LOGIC - REMOTE
SCHEMATIC DIAGRAM



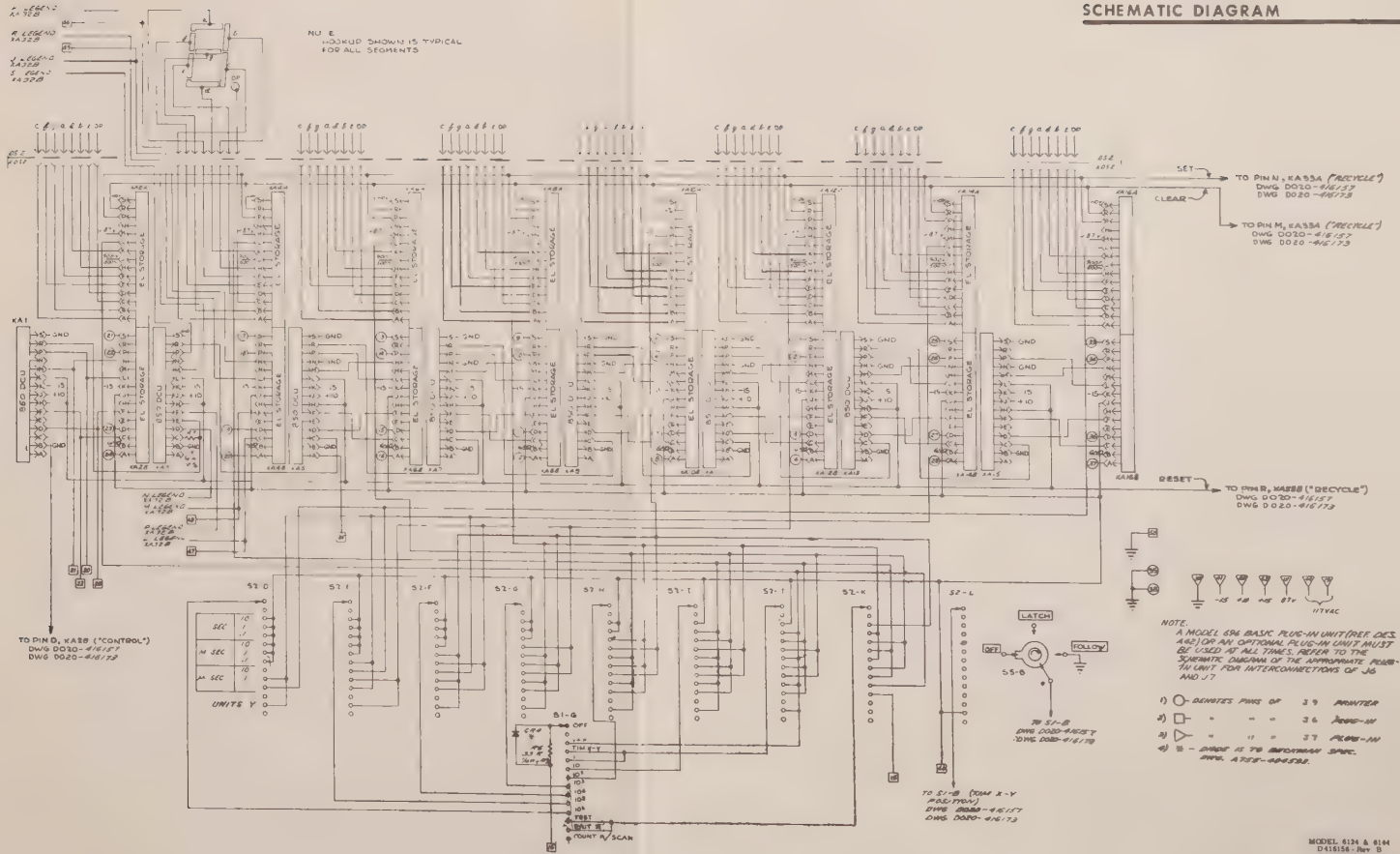
Beckman


P6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50
P6

MODEL 6144
UNIT LOGIC
SCHEMATIC DIAGRAM

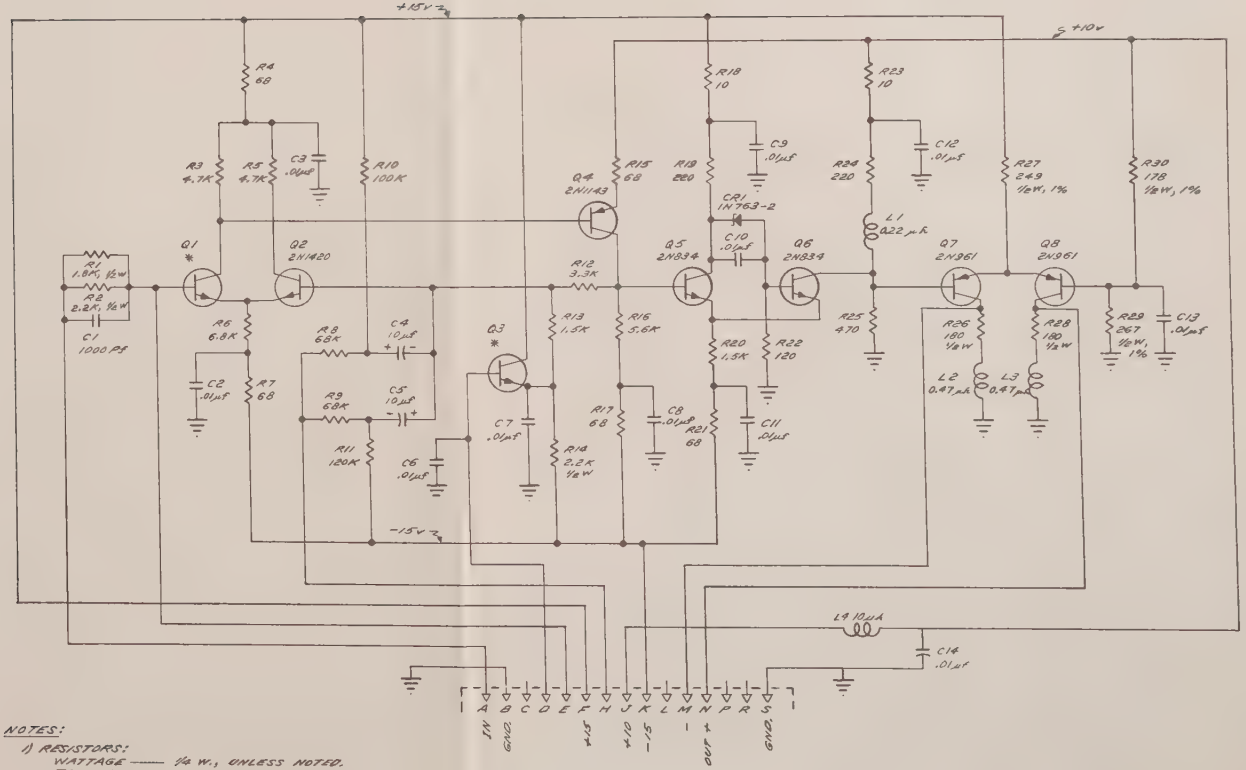

TRIGGER LEVEL
TIME BASE DCUPL
NOTES:
A MODEL 6144 BASIC PLUG-IN (PART
NO. 446108 AS OPTIONAL PACKAG-
ING UNIT MUST BE USED AT ALL
TIMES. REFER TO THE SCHEMATIC
DIAGRAM FOR THE APPROPRIATE
PLUG-IN UNIT ROW INTER-
CONNECTIONS OF J6 AND J7
UNIT 3

MODEL 6124 & 6144
COUNT LOGIC
SCHEMATIC DIAGRAM



MODEL 6124 & 6144
D416156 - Rev B
September 1963
Beckman
Lot 3-

MODEL 6124 & 6144
2.5 MC AMPLIFIER
SCHEMATIC DIAGRAM

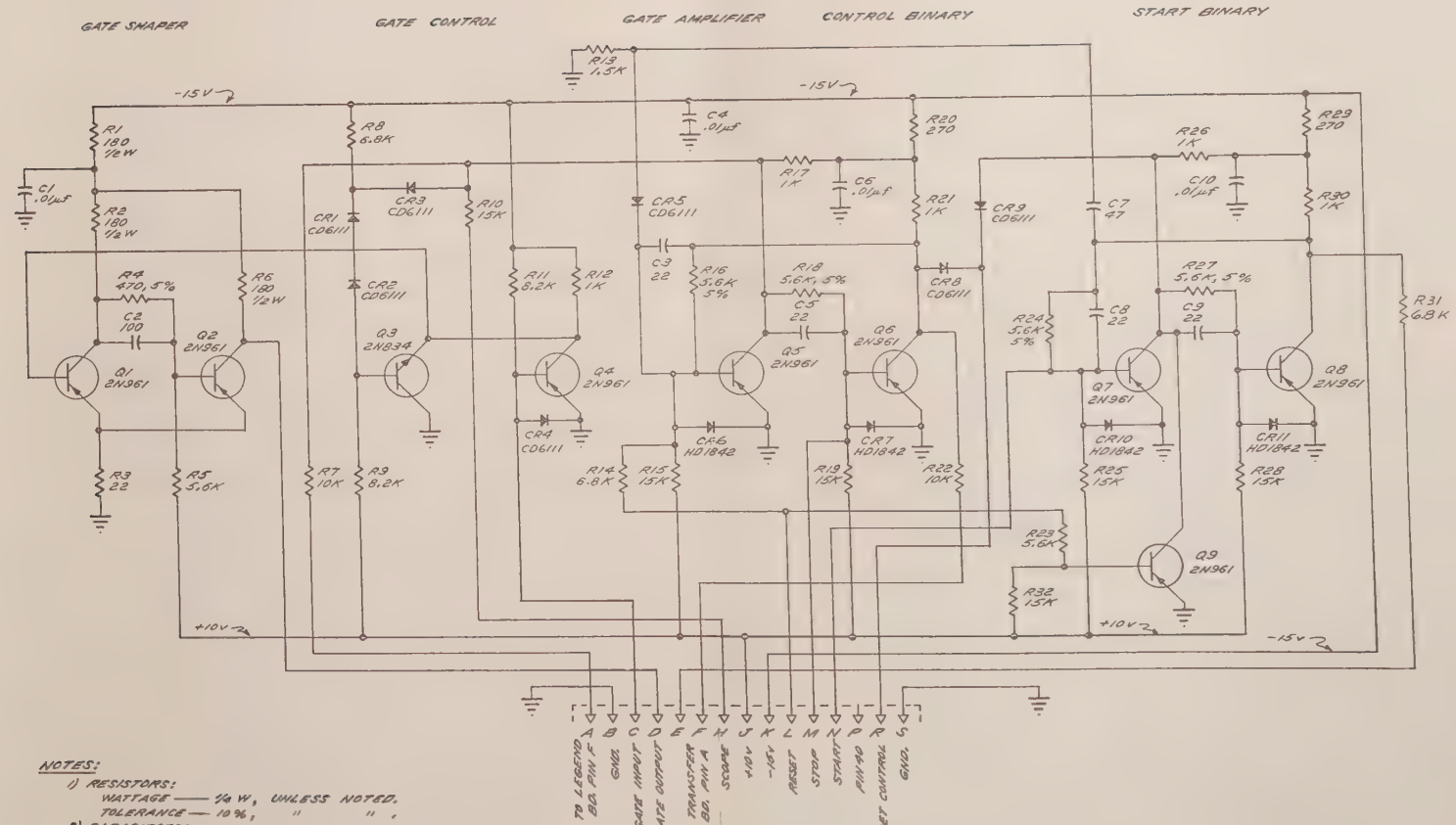


NOTES:

1) RESISTORS:
   WATTAGE ——— 1/4 W., UNLESS NOTED.
   TOLERANCE — 5%, " " .
2) CAPACITORS:
   PF CAPACITORS ARE 300V., 5%, UNLESS NOTED.
3) .01µF DISCS ARE -20+80%, 500V.
4) * TRANSISTORS ARE TO BECKMAN SPEC. DWG. A755-403835.

MODEL 6124 & 6144
C-616020 - Rev. B
September 1963
Beckman
Lot 3-

MODEL 6100 SERIES
CONTROL
SCHEMATIC DIAGRAM



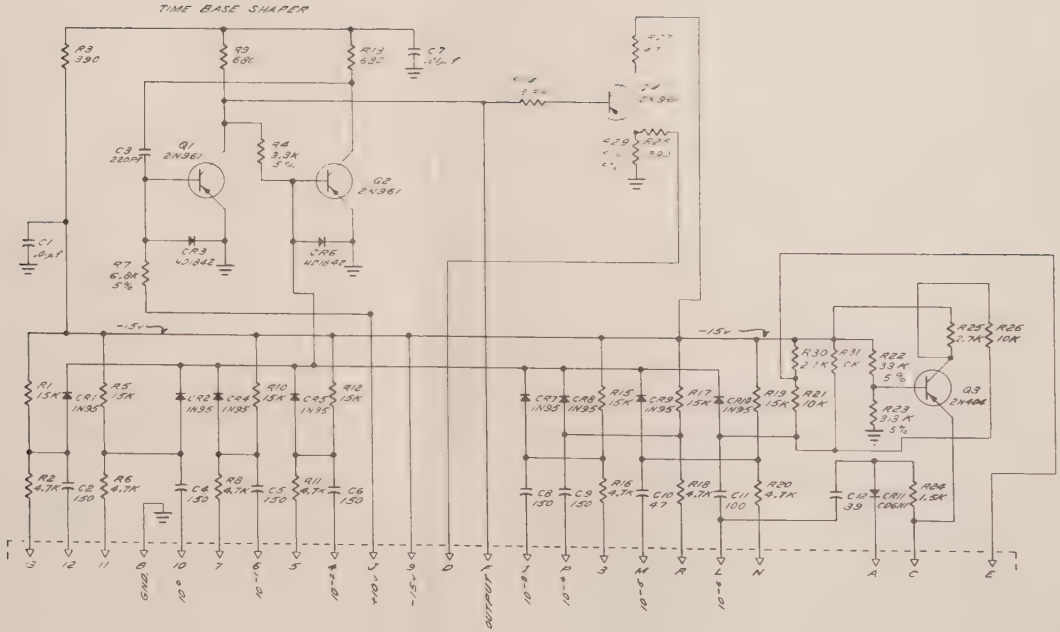
NOTES:

1) RESISTORS:
   WATTAGE — 1/2 W, UNLESS NOTED.
   TOLERANCE — 10%, " "
2) CAPACITORS:
   CAPACITY — IN PF, " "
   VOLTAGE — 300 V, " "
   TOLERANCE — 5%, " "
3) .01µf DISC ARE -20 +80%, 500 V.

6134, 6144, 6136, 6146
C-411890 - Rev. D
August 1963

Beckman®

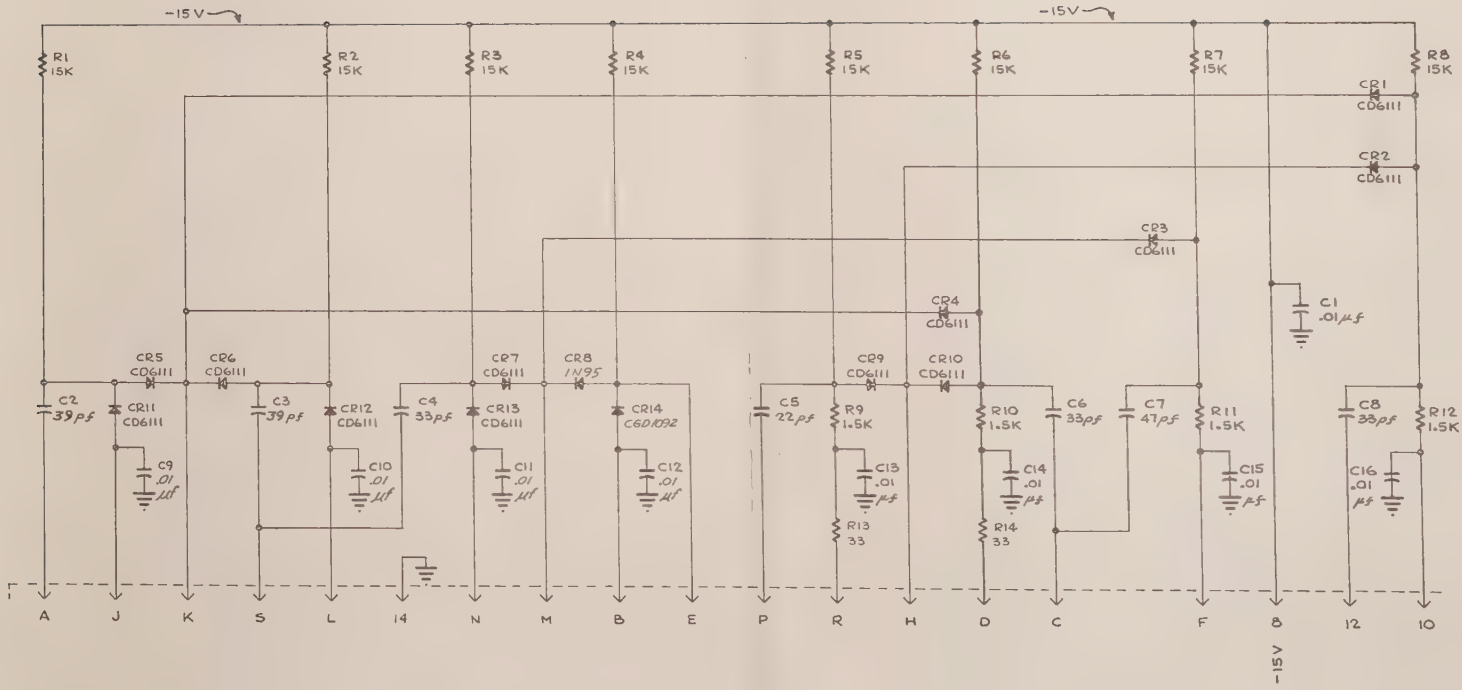
P. C. Board Lot 2+



NOTE:

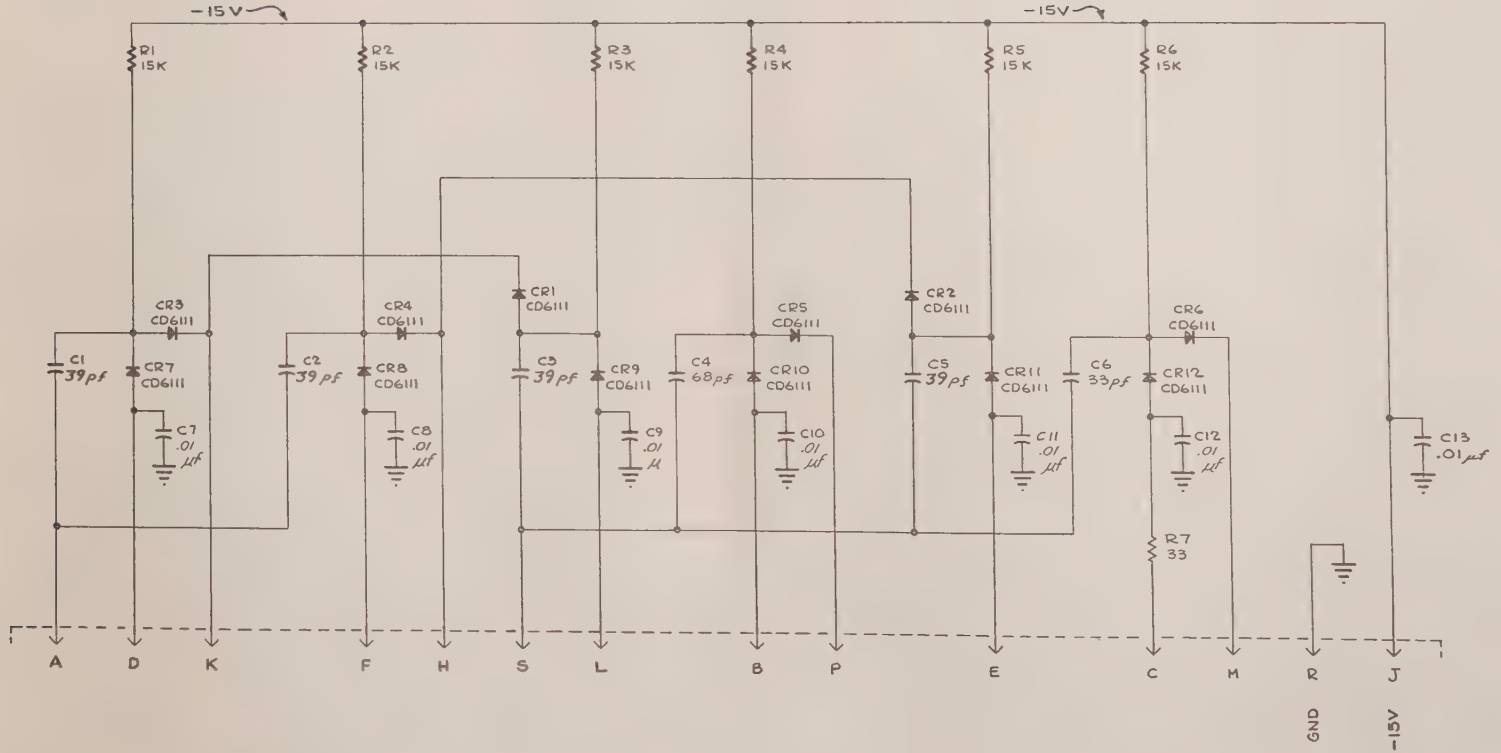
1) RESISTORS:
   WATTAGE —— 1/2W, UNLESS NOTED.
   TOLERANCE —— 10%, " " .
2) CAPACITORS:
   CAPACITY —— IN pf, " " .
   VOLTAGE —— 300v, " " .
   TOLERANCE —— 5%, " " .
3) .01µf DISC ARE -80+80%, 500v.

MODEL 6100 SERIES
"F" LOGIC
SCHEMATIC DIAGRAM



NOTE:
1) RESISTORS:
WATTAGE — 1/4 W, UNLESS NOTED
TOLERANCE — 10%, " "
2) CAPACITORS:
CAPACITY — IN PF, " "
VOLTAGE — 300 V, " "
TOLERANCE — 5% , " "
3) .01µf DISC ARE -20+80%, 500v

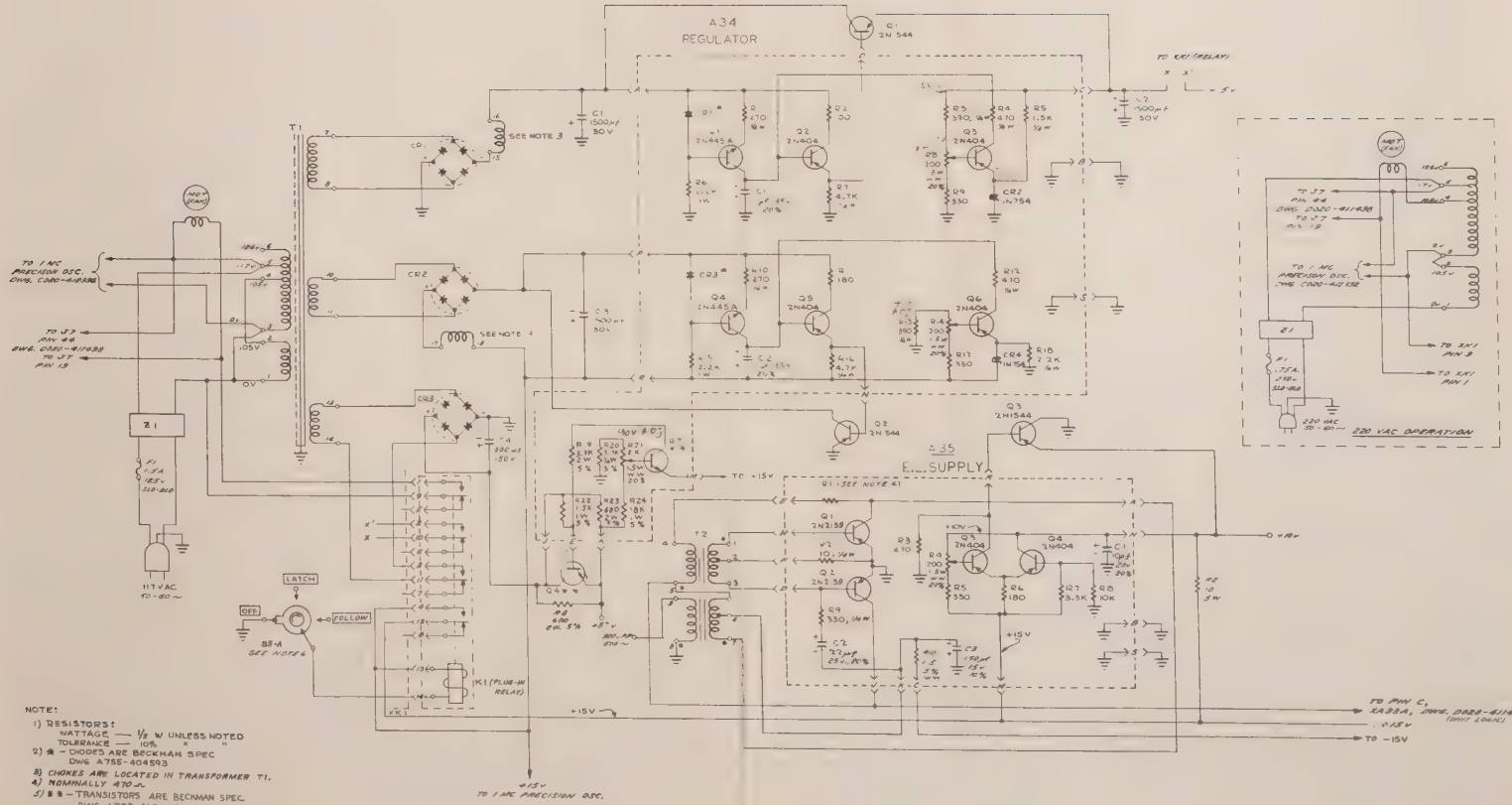
MODELS
6124, 6144, 6136, 6148
C411113 - Rev. B
August 1963
Beckman
P. C. Board Lot 3-



NOTE:
RESISTORS:
WATTAGE — 1/4 W, UNLESS NOTED.
TOLERANCE — 10%, " "
CAPACITORS:
VOLTAGE — 300 v, " "
TOLERANCE — 5%, " "
.01 µf DISCS ARE -20 +80%, 500 V

6134, 6144, 6136, 8168
C413443 - Rev. B
August 1963
Beckman
P. C. Board Lot 2.

POWER SUPPLY
SCHEMATIC DIAGRAM

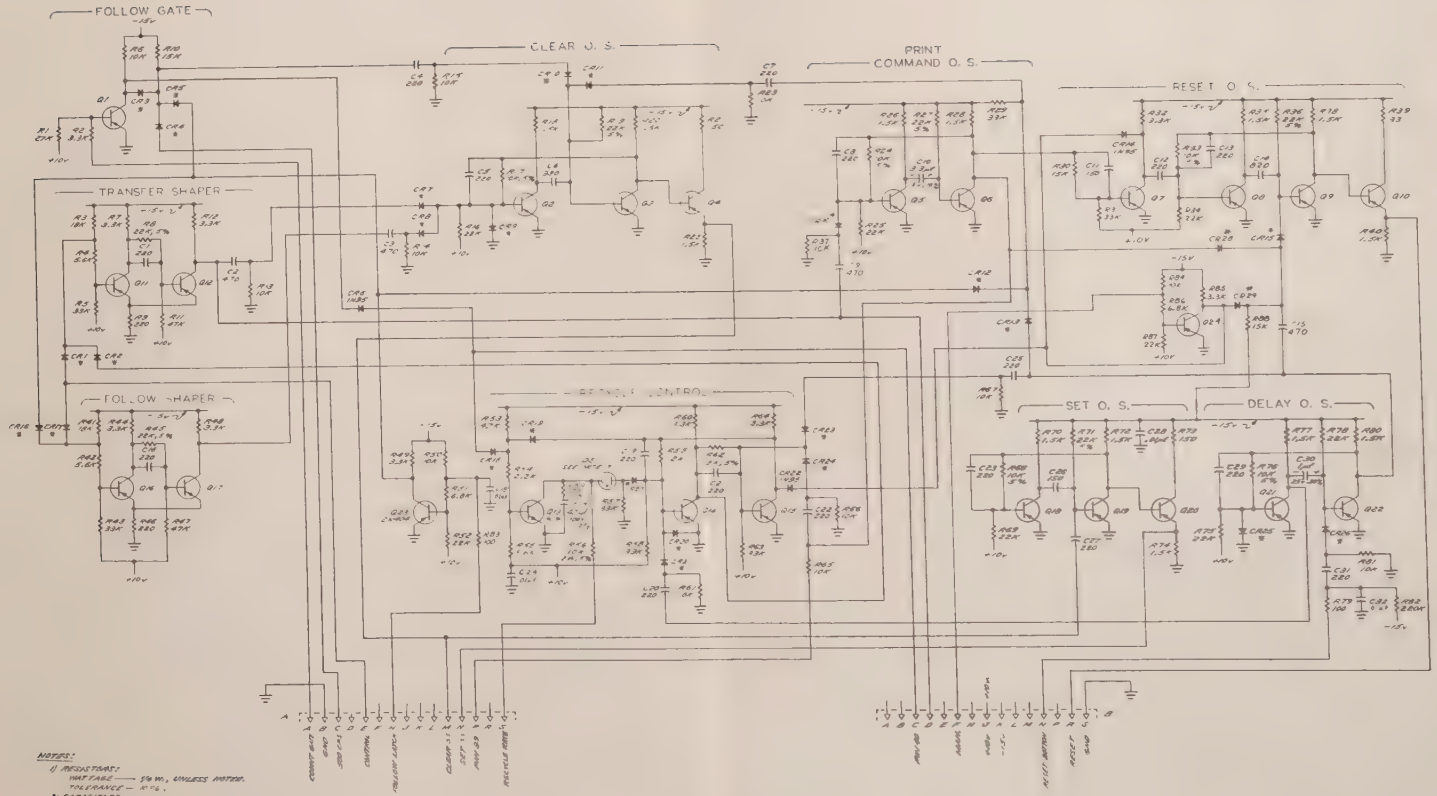


NOTE:

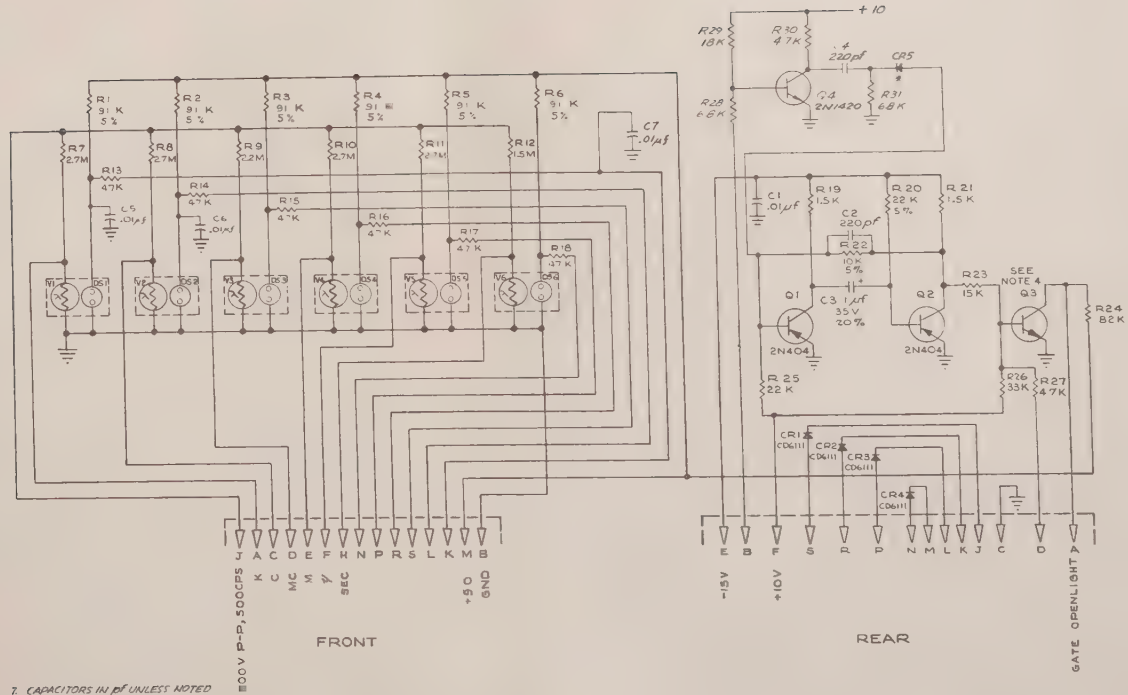
1) RESISTORS:
   WATTAGE — 1/8 W UNLESS NOTED
   TOLERANCE — 10% " "
2) ★ - DIODES ARE BECKMAN SPEC DWG A7SS-404593
3) CHOKES ARE LOCATED IN TRANSFORMER T1.
4) NOMINALLY 470 Ω.
5) ★★ - TRANSISTORS ARE BECKMAN SPEC. DWG A7SS-415078
6) ON 6120-21 LATCH BECOMES POWER ON FOLLOW NOT USED

Models 6124, 6144, 6127, 6147
D411976-Rev J
March 1965

Beckman



NOTES:
1) RESISTORS:
WATTAGE —— 1/4 W., UNLESS NOTED.
TOLERANCE — 10%.
2) CAPACITORS
CAPACITY —— IN PF.
VOLTAGE — 100 V., "
TOLERANCE — 5%, "
3) 100 PF DISC ARE -20 + 80 %, 500 V.
4) ‡ — DIODES ARE TO BECKMAN SPEC.
DWG. A755-604559.
5) ‡‡ — TRANSISTOR TO BECKMAN SPEC.
DWG. A755-610066.
6) ALL TRANSISTORS ARE 2N404, UNLESS NOTED.
7) QS1 - 12 TO BECKMAN SPEC.
DWG. A825-610356.

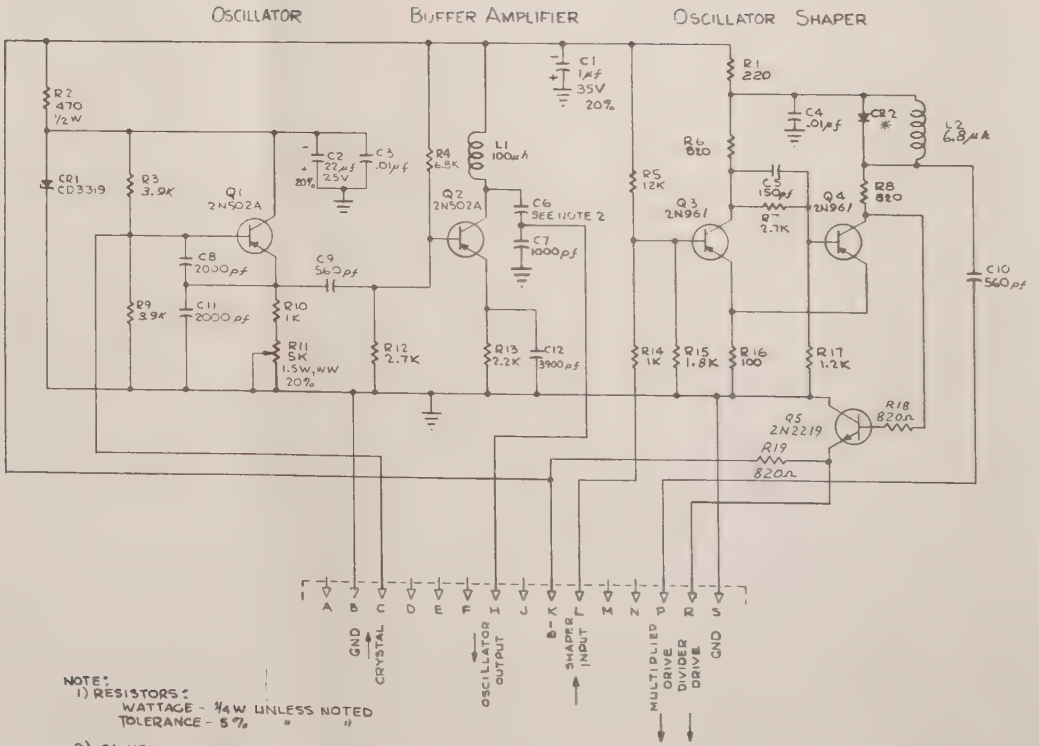


7. CAPACITORS IN pf UNLESS NOTED
   TOLERANCE - 5% "
   VOLTAGE - 300 V "
6. .01μf DISC ARE -20+80%, 500 V
5. CR5 IS BDB # 755-404593
4. Q3 IS BECKMAN PART NO. 755-410066.
3. ALL NEON BULBS TO BE BDB 825-414955.
2. ALL PHOTO CONDUCTORS TO BE BDB 416278.
1. ALL RESISTORS ¼W, ±10%

NOTES: (UNLESS OTHERWISE SPECIFIED)

MODELS:
6134, 6144, 6138, 6148
C4111783-Rev C
February 1964
Beckman
Lot 3

MODEL 6124 & 6144
1 MC OSCILLATOR & SHAPER
SCHEMATIC DIAGRAM



NOTE:

1) RESISTORS:
   WATTAGE - ¼W UNLESS NOTED
   TOLERANCE - 5% " "

2) C6 NOMINALLY 300pf. IF OSCILLATOR OUTPUT IS LESS THAN 3V PP, CHANGE TO 330pf

3) CAPACITORS:
   TOLERANCE — 5% UNLESS NOTED
   VOLTAGE — 300V " "

4) .01µf DISC ARE -20+80%, 500V

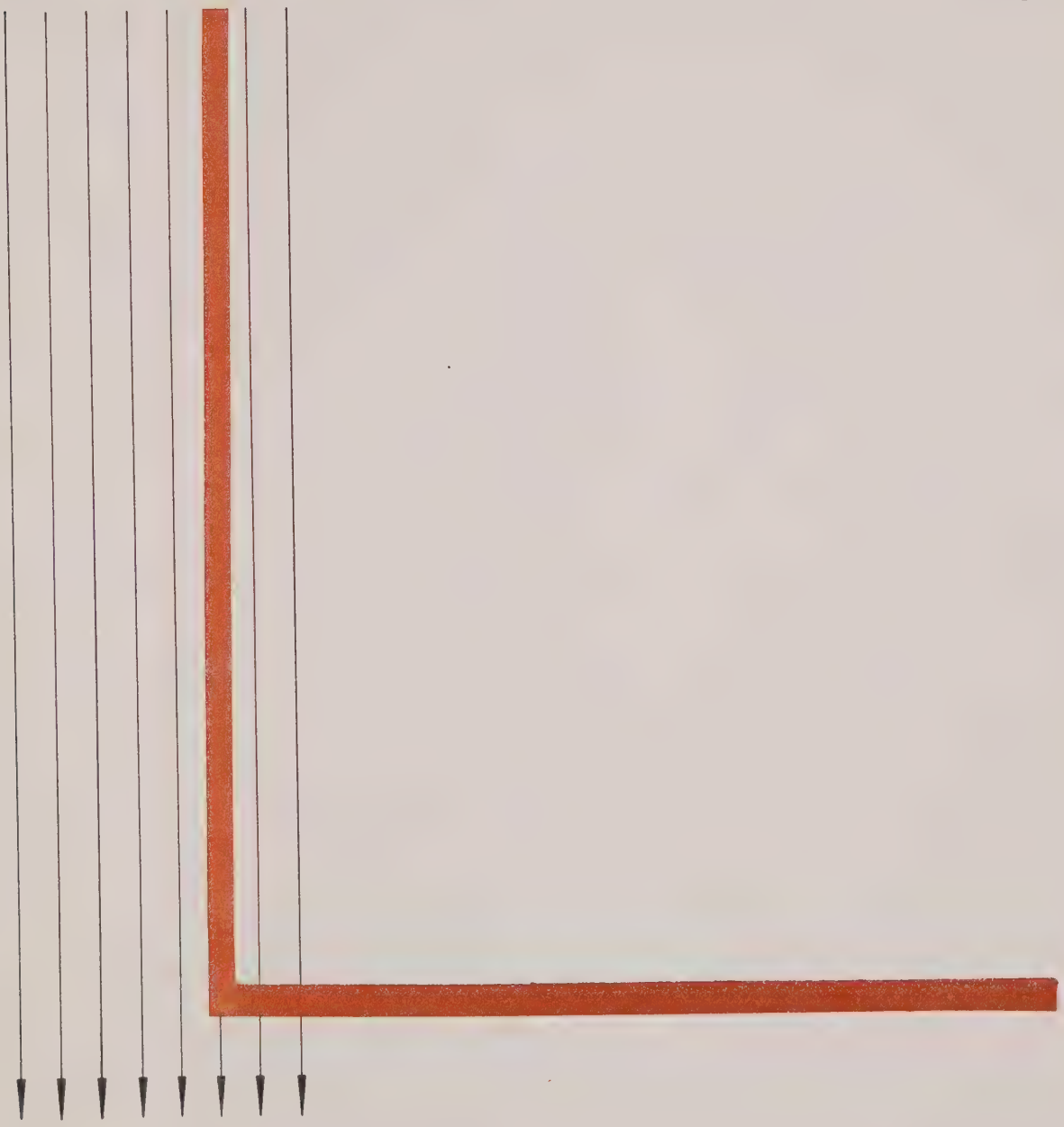
* 5) CR2 IS BDB #755-402107

MODEL 6124 & 6144
C 611896 - Rev. C
September 1963

Beckman

INSTRUCTION MANUAL

MODEL 850
Decimal Counting Unit



Beckman® INSTRUMENTS, INC.
BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

December 1962

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

The exceptions and conditions mentioned above are the following:

(a) Some components and accessories by their nature are not intended to, and will not, function one year. If any such component or accessory manufactured by the Company and part of the item sold fails to give reasonable service for a reasonable period of time, the Company will, at its election, replace or repair such component or accessory. What constitutes reasonable service and what constitutes a reasonable period of time shall be determined solely by the Company after the Company is in posession of all the facts concerning operating conditions and other pertinent factors and after such component or accessory has been returned to the Company, transportation prepaid.

(b) All instruments claimed defective must be returned to the Company, transportation charges prepaid, and will be returned to the customer with the transportation charges collect, unless the item is found to be defective in which case the Company will pay all transportation charges.

(c) The Company makes no warranty concerning components or accessories not manufactured by it, such as tubes, fuses, batteries, etc. However, in the event of the failure of any component or accessory not manufactured by the Company, the Company will give reasonable assistance to the purchaser in obtaining from the respective manufacturer whatever adjustment is reasonable in the light of the manufacturer's own warranty.

(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

(f) Representations and warranties made by any person, including representatives of the Company, which are inconsistent or in conflict with the terms of this warranty (including but not limited to the limitation of the liability of the Company as set forth above) shall not be binding upon the Company unless reduced to writing and approved by an officer of the Company.

(g) This warranty shall be governed by the laws of the State of California.

Claims for damage in shipment should be filed promptly with the transportation company.

All correspondence concerning the instrument should specify the model and serial number. This information appears on the company name plate. Any inquiry concerning details of operation, possible modifications, etc., should be addressed to the Sales Department, Berkeley division of Beckman Instruments, Inc., Richmond 4, California.

REPAIR SERVICE

Experienced service personnel and special test equipment are available at the factory to perform any necessary repairs. Every effort will be made to expedite the repair of instruments returned for servicing. Repair work will be performed only upon receipt of a written purchase order or authorization. Instruments to be repaired should be addressed to SERVICE AND REPAIR DEPARTMENT with transportation charges prepaid. Repaired instruments will be returned to the purchaser with transportation charges collect.

Berkeley reserves the right to make changes in design at any time without incurring any obligation to modify equipment previously purchased to conform to subsequent design changes.

BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model 850 DCU is a plug-in electronic counting unit using solid state components mounted on a printed circuit board. The unit counts input pulses from zero to nine; each count is represented by output signals in binary (1-2-4-8) coded form. With an Electroluminescent Storage Unit this binary-coded output can be converted into a decimal digit display of the registered count.

At every tenth input pulse, the DCU generates an output signal suitable to drive another Model 850 DCU. Thus, any number of these units can be cascaded (the output of one connected to the input of the next) to form a counter whose total count capacity depends only on the number of DCU's.

Since each DCU generates one output pulse for every ten input pulses, these units can also be used as decade frequency dividers.

1.2 TECHNICAL CHARACTERISTICS

Count Indication

Binary-coded (1-2-4-8) electrical signals

Input Requirements

Voltage pulse, +10 to +25 volts amplitude*, 1μs minimum duration (0.5μs rise time).

Maximum Counting Rate

250,000 counts per second

Resolution of Paired Pulses

3 microseconds

---

*The values given correspond to supply voltage levels listed under "Power Requirements". For values when other supply voltages are used, see Section 2.6.

Output Characteristics

Positive signal when count goes from "9" to "0", suitable for driving another Model 850 DCU.

Reset Requirement

Voltage pulse, -10 v amplitude*, 10μs minimum duration.

Power Requirements

22 ma at -15 v. (±5%)
2 ma at +10 v. (±5%)

(NOTE: The unit can operate at other voltage levels as well; see see Section 2.6).

Construction

Printed card plug-in unit (with 15-pin printed circuit connector).

Dimensions

1/2 inch wide, 3 11/16 inches high, 3 5/32 inches deep

Weight

1 1/2 oz.

*The values given correspond to supply voltage levels listed under "Power Requirements". For values when other supply voltages are used, see Section 2.6.

SECTION 2

OPERATION

2.1 MOUNTING THE UNIT

The DCU can be mounted by plugging into a 15 pin printed-card-connector. Typical connector: Ucinite 119510-MP-15C.

2.2 SUPPLYING POWER

Ordinarily, the unit operates with supply voltages of -15 volts and +10 volts, but other voltage levels can be substituted as indicated in Section 2.6. The negative voltage supply should be connected to pin K of the DCU connector, while the positive supply should be connected to pin J.

2.3 SUPPLYING INPUT SIGNALS

Connect the source of input signals to pin C of the DCU connector. The unit will register a count each time a pulse +10 to +25 volts in amplitude (with a minimum width of 1μs and a 0.5μs rise time) is applied to the input terminal.

Pin A (capacitor bypass) provides an alternate input. If used, this input should be driven through an external capacitor.

2.4 USING OUTPUT SIGNALS

The DCU supplies readout signals to terminals D, F, M, and P of the DCU connector. These signals are in two voltage states: -12 volts with respect to ground (pin S) for the binary "one", and -0.3 volts with respect to ground for the binary "zero". The binary states (each binary driving one readout line) represent the registered count in 1-2-4-8 binary code. Each readout line will supply a maximum steady state current of 2 ma into a load connected to B-. Table 1 indicates the state of the binaries for each registered count from 0 to 9.

Use Table 1 to convert a coded digit to a decimal digit. Note the weight of each column in which a "1" appears, then sum the weight. For example, the coded digit "1100" is equivalent to 1+2+0+0=3; and "0110" is equivalent to 0+2+4+0=6.

Table 1. State of the Binaries

DECIMAL DIGIT REGISTERED	FIRST BINARY STAGE (Weight 1)	SECOND BINARY STAGE (Weight 2)	THIRD BINARY STAGE (Weight 4)	FOURTH BINARY STAGE (Weight 8)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

The readout signals at terminals D, F, M and P drive an Electroluminescent Storage Unit for a visual indication of the registered count. In addition, the output signal produced at terminal R each time the count goes from 9 to 0 can be used to drive another Model 850 DCU or other circuitry.

2.5 RESETTING DCU TO ZERO

Reset lines H, L, and N are clamped at zero volts while the DCU counts. A negative pulse to lines H and L (line N clamped at zero volts) will reset the DCU to zero. The DCU can be set to 9 by applying a negative pulse to lines L and N (line H clamped at zero volts). A 10 microsecond, -10 volt pulse will reset the DCU. The reset pulse can be generated either electronically by transistor circuitry or mechanically through relay contacts.

2.6 SPECIAL OPERATING CONDITIONS

Although the operating characteristics described in previous sections are for power supply levels of -15 and +10 volts, the unit will function at other voltages as well. Proper combinations of B- and B+ voltages down to -8 and +4 volts respectively can successfully be used.

Those characteristics which are affected by the supply voltage levels will naturally vary with the value of the voltages used. Thus, for example, with a B- and B+ voltage of -8 and +4 volts, the amplitudes of the input, output, and reset signals will be approximately as follows (signal widths remain unchanged):

1) Input signal: +5 to +15 volts

2) Output signal: Potentials of 0 and -6 volts with respect to ground.

3) Reset signal: -10 volts

SECTION 3

CIRCUITS

3.1 THE BINARIES

The decimal counting unit consists of four binaries, each comprising a pair of p-n-p transistors connected in a scale-of-ten circuit. The transistor binaries are similar to vacuum tube binaries in that they have two stable states, and are alternately triggered from one state to the other by successive input pulses.

The major difference between the two types of binary is the operating characteristics of the transistors. In a transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low impedance allows a base current to flow and the transistor can conduct. On the other hand, a positive base potential results in a high input impedance (several hundred thousand ohms). Consequently, no base current flows and the transistor is cut off.

Assume, for example, that the first binary on the schematic diagram is initially in the "zero" state. In this state, Q2 is conducting while Q1 is cut off. A positive input voltage pulse applied through diode CR3 to the base of Q2 drives this transistor to cutoff. As a result, the base current that normally flows is diverted and Q2, therefore, stops conducting.

The same input pulse which is applied to CR3 cannot change the state of Q1 since this transistor is already cut off.

As the load current in Q2 decreases, the potential on its collector approaches B-. This change in voltage level, coupled through resistor R2 and capacitor C1 to the base of transistor Q1, drives Q1 into the active region. As a result, Q1 begins to conduct, and the amplified current flowing through R4 causes the potential on the collector to fall almost to zero. Under these conditions, the divider network consisting of R9 and R7 supplies a large enough positive potential to the base of Q2 to keep it cut off.

The binary, now in the "one" state, remains in this stable state until the next positive input pulse arrives. When this happens, Q1 is cut off, Q2 conducts, and the binary thus resumes its original state.

The collectors Q1, Q3, Q5, and Q7 are tied to terminals D, F, M, and P, respectively, of the DCU connector. A change in voltage level at each collector as the binary changes state is available as an output signal. In addition, one output of each binary is used as input to the following binary. Therefore, each binary in the DCU reverses state for every two reversals of the preceding binary.

3.2 THE SCALE-OF-TEN CIRCUIT

The scale-of-ten circuit used in the Model 850 DCU is actually a four-place binary counter wired so that it resets to zero on every tenth input pulse. Thus, for the first nine pulses, the binaries operate as in a conventional, 1-2-4-8 counter. At the count of eight, however, the negative potential on the collector of Q8 is fed back through R15 to the second binary. This places a bias on CR4 and CR5 so that the next positive pulse from Q2 will not trigger the second binary.

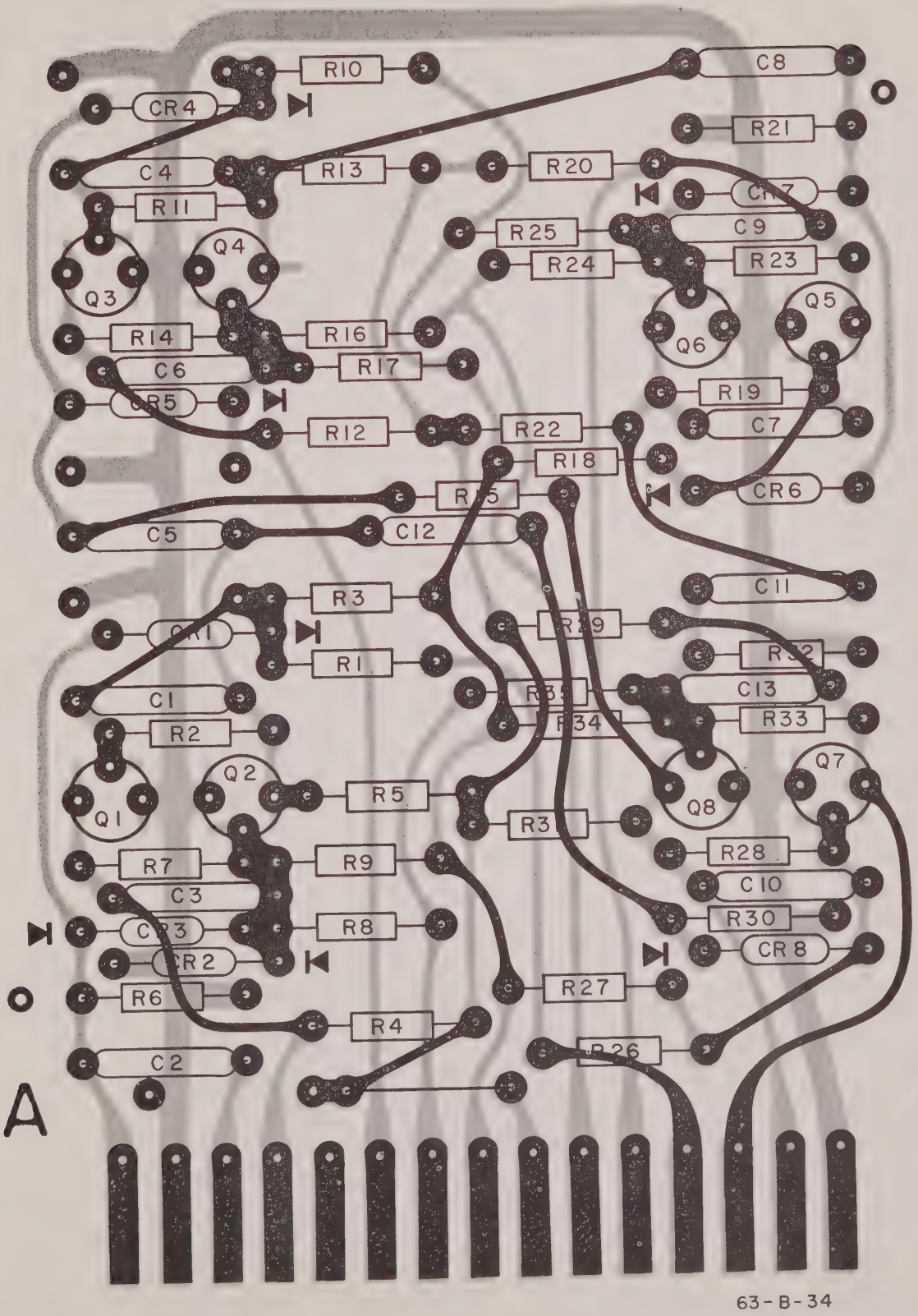
The tenth input pulse, then, flips the first binary to its "zero" state, but the corresponding positive transient at the collector of Q2 cannot trigger the second binary to the "one" state. However, this positive transient, coupled through C12 does trigger the fourth binary to its "zero" state.

At the tenth input pulse, therefore, all four binaries are in the "zero" state, the bias on CR2 and CR5 has been removed, and the circuit is ready for the next counting cycle.

The positive output signal from Q8, produced when the counter goes from nine to zero, can be used to drive another Model DCU. Thus, the DCU will supply one input pulse to the next DCU for every ten counts registered.

The number of counts registered by the DCU is represented in binary-coded form by the potentials on the binary readout lines. Only one output signal is available from each binary.

Reset lines H and L connect through a corresponding resistor to the base of the right-hand transistors (Q2, Q4, Q6, and Q8) of each binary. Reset line N connects to the base of the left-hand transistors (Q1 and Q7) of each binary. A negative voltage pulse applied to reset lines H and L (line N clamped at zero) will turn on all transistors on the right-hand side of each binary, setting the DCU to zero. A negative voltage pulse applied to reset lines L and N (line H clamped at zero) sets the DCU to nine.



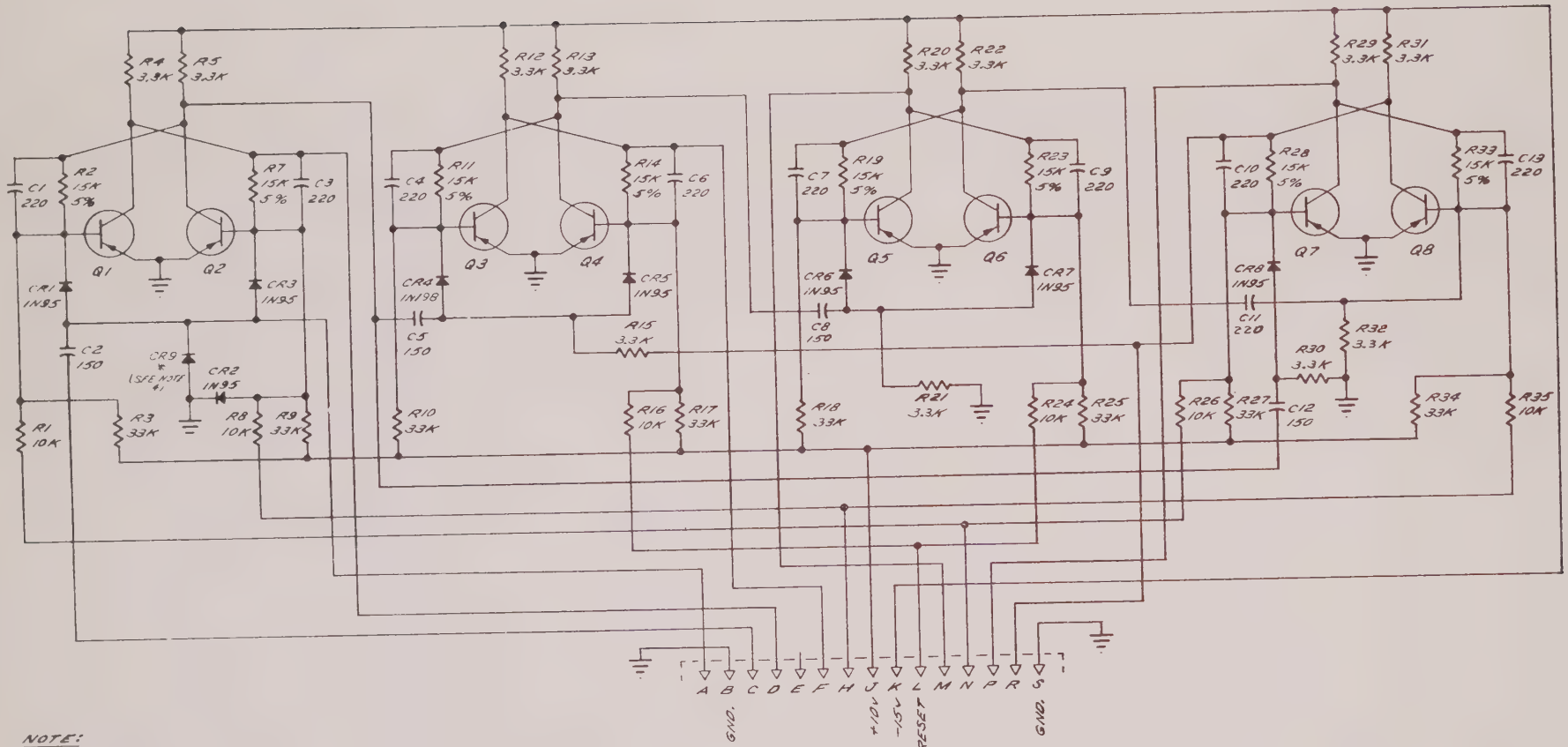
MODEL 850 DCU COMPONENT LAYOUT

SECTION 4

PARTS LIST

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
C1	637-824020	Capacitor, F. Mica, 220pf, 300V, 5%	9
C2	637-824018	Capacitor, F. Mica, 150pf, 300V, 5%	4
C3 & C4		Same as C1	
C5		Same as C2	
C6 & C7		Same as C1	
C8		Same as C2	
C9 thru C11		Same as C1	
C12		Same as C2	
C13		Same as C1	
CR1	755-402107	Diode, special	7
CR2 & CR3		Same as CR1	
CR4	755-800274	Diode, Germanium, 80 PIV, 4 ma, 1V min. fwd.	1
CR5 thru CR8		Same as CR1	
CR9	755-402107	Diode, special	1
Q1	755-800398	Transistor, Germanium, PNP, 150mw max.	8
Q2 thru Q8		Same as Q1	
R1	601-823108	Resistor, F. Comp., 10K, 1/4W, 10%	6
R2	601-822301	Resistor, F. Comp., 15K, 1/4W, 5%	8
R3	601-823109	Resistor, F. Comp., 33K, 1/4W, 10%	8
R4	601-823942	Resistor, F. Comp., 3.3K, 1/4W, 10%	12
R5		Same as R4	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R7		Same as R2	
R8		Same as R1	
R9 & R10		Same as R3	
R11		Same as R2	
R12 & R13		Same as R4	
R14		Same as R2	
R15		Same as R4	
R16		Same as R1	
R17 & R18		Same as R3	
R19		Same as R2	
R20 thru R22		Same as R4	
R23		Same as R2	
R24		Same as R1	
R25		Same as R3	
R26		Same as R1	
R27		Same as R3	
R28		Same as R2	
R29 thru R32		Same as R4	
R33		Same as R2	
R34		Same as R3	
R35		Same as R1	
	864-412958	Pad, converter transistor	8



NOTE:

1) RESISTORS:
   - WATTAGE ——— 1/2 W., UNLESS NOTED.
   - TOLERANCE —— 10%, " " .
2) CAPACITORS:
   - CAPACITY ——— IN PF, " " .
   - VOLTAGE ——— 300 V, " " .
   - TOLERANCE —— 5%, " " .
3) TRANSISTORS ARE — 2N404.

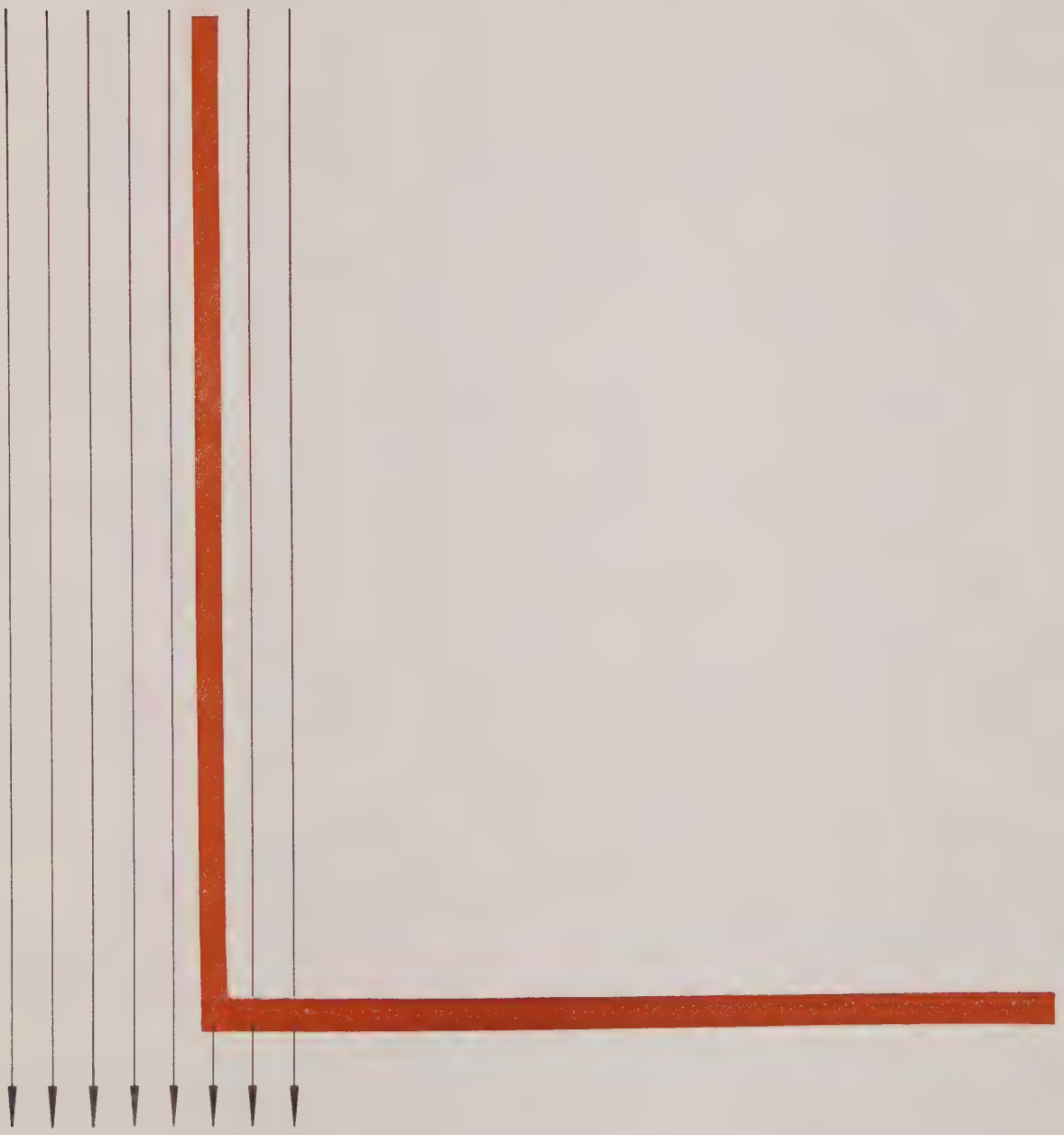
4) * DIODE IS BECKMAN SPEC. 35-4-21.27.

MODEL 850 DCU
C411930-Rev. C
January 1964

Beckman®

INSTRUCTION MANUAL

MODEL 860
Decimal Counting Unit



Beckman® INSTRUMENTS, INC.

BERKELEY DIVISION
2200 Wright Avenue
Richmond, California

December 1962

WARRANTY

Instruments sold by Berkeley Division, Beckman Instruments, Inc., (hereafter called "the Company") are warranted only as stated below.

Subject to the exceptions and upon the conditions specified below, the Company agrees to correct, either by repair, or, at its election, by replacement, any defect of material or workmanship which develops within one year after delivery of the instrument to the original purchaser by the Company or by an authorized representative, provided that investigation and factory inspection by the Company discloses that such defect developed under normal and proper use.

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(d) Except as stated above, the Company makes no warranty, express or implied (either in fact or by operation of law), statutory or otherwise; and, except to the extent stated above, the Company shall have no liability under any warranty, express or implied (either in fact or by operation of law), statutory or otherwise.

(e) The Company expressly disclaims any liability to its customers, dealers, and to users of its products, and to any other person or persons for consequential damages of any kind and from any cause whatsoever arising out of or in any way connected with the manufacture, sale, repair, replacement of, or arising out of or in any way connected with the use of any of its products.

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BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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DIAGRAMS

Model 860 DCU Component Layout 3-5

Model 860 DCU Schematic Diagram (D411932-Rev. B)

SECTION 1

INTRODUCTION

1.1 GENERAL DESCRIPTION

The Model 860 DCU is a plug-in electronic counting unit using solid state components mounted on a printed circuit board. The unit provides a count of input pulses from zero to nine, each count being represented by output signals in binary (1-2-4-8) coded decimal form. With an Electroluminscent Storage Unit this binary-coded output can be converted into a decimal digit display of the registered count.

At every tenth input pulse, the DCU generates an output signal suitable to drive a Model 850 or a Model 860 DCU. Thus, any number of these units can be cascaded (the output of one connected to the input of the next) to form a counter whose total count capacity depends only on the number of DCU's.

Since each DCU generates one output pulse for every ten input pulses, these units can also be used as decade frequency dividers.

1.2 TECHNICAL CHARACTERISTICS

Count Indication

Binary-coded decimal (1-2-4-8) electrical signals.

Input Requirements

Positive pulse or voltage step, 6 volts to 8 volts amplitude (+7.0 recommended), 10 nanoseconds rise-time. Pulse duration 30 nanoseconds, minimum.

Counting Rate

2.5 megacycles, maximum

Output Characteristics

1-2-4-8 permuted binary code

Output available from one side of each binary. Voltage levels -0.2 volts and -13.0 volts. Binaries designed to drive maximum of 2 ma through 7.5 K to the negative supply of -15 volts.

Carry pulse output designed to drive a following Model 860 DCU or Model 850 DCU.

Designed to drive 1.5 ma into Electroluminescent Storage Unit from "off" side of binaries.

Reset Requirements

Negative pulse or voltage level change. Reset time held at 0 volts. At reset, line is driven to -10 volts for 10 microseconds.

Power Requirements

45 ma at -15 volts and 4.0 ma at +10 volts.

Transfer Time

100 nanoseconds between application of tenth input pulse and start of output pulse.

Transistors

Germanium, two 2N960 and six 2N968. Soldered into circuit.

Demensions

1/2 inch wide, 3-11/16 inches high, 3-5/32 inches deep.

Weight

1-1/2 oz.

Connector Required

UCINITE 119510-MP-15C. Beckman 20N 680 815353.

SECTION 2

OPERATION

2.1 MOUNTING THE UNIT

The DCU plugs into a 15-pin printed-card connector. Typical connector: Ucinite 119510-MP-15C.

2.2 SUPPLYING POWER

Ordinarily, the unit operates with supply voltages of -15 volts and +10 volts. The negative voltage supply connects to pin K of the DCU connector, and the positive supply to pin J. Supply voltage tolerance ±10%.

2.3 SUPPLYING INPUT SIGNALS

Connect the input signal to pin C of the DCU connector. The unit registers a count each time a pulse +6 to +8 volts in amplitude (with a minimum width of 30 nanoseconds and a 10 nanoseconds rise time) is applied to the input terminal.

Pin A (capacitor bypass) provides an alternate input. If used, this input should be driven through an external capacitor.

2.4 USING OUTPUT SIGNALS

Each of the DCU's four binaries supply readout signals in two forms: with a B- supply of -15 volts, -12 volts with respect to ground (pin S) for a binary "one", and -0.3 volts with respect to ground for a binary "zero". The binary states of "one" or "zero" indicate the registered count in 1-2-4-8 binary coded decimal. Each readout line will supply a maximum steady state current of 2 ma into a load connected to B-. Table 1 represents the binary state for each registered count from 0 to 9.

The readout signals at terminals D, F, M, and P, can be used to drive the Electroluminescent Storage Unit for a visual indication of the registered count. In addition, the output signal produced at terminal R each time the count goes from 9 to 0 can drive either a Model 850 or 860 DCU or other circuitry.

Table 1. State of the Binaries

DECIMAL DIGIT REGISTERED	FIRST BINARY STAGE (Weight 1)	SECOND BINARY STAGE (Weight 2)	THIRD BINARY STAGE (Weight 4)	FOURTH BINARY STAGE (Weight 8)
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

Use Table 1 to convert a coded digit to a decimal digit. Note the weight of each column in which a "1" appears, then sum the weights. For example, the coded digit "1010" is equivalent to 1+0+4+0=5; and "1001" is equivalent to 1+0+0+8=9.

2.5 RESETTING DCU TO ZERO

Reset lines H, L, and N are clamped at zero volts while the DCU counts. Applying a negative pulse to lines H and L (line N clamped at zero volts) resets the DCU to zero. If desired, the DCU can be set to 9 by applying a negative pulse to lines L and N (line H clamped at zero volts). A 1 microsecond, -10 volt pulse is necessary to effect reset. The reset pulse can be generated either electronically by transistor circuitry or mechanically through relay contacts.

SECTION 3
CIRCUITS

3.1 THE BINARIES

The decimal counting unit consists of four binaries, each comprising a pair of p-n-p transistors, connected in a scale-of-ten circuit. The binaries have two stable states and are alternately triggered from one state to the other by successive input pulses.

In a p-n-p transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low input impedance permits a base current to flow and the transistor conducts. On the other hand, a positive base potential results in a high input impedance (several hundred thousand ohms). Consequently no base current flows and the transistor is cut off.

Assume, for example, that the first binary on the schematic diagram is initially in the "zero" state. In this state, Q2 is conducting while Q1 is cut off. A positive input pulse applied through diode CR4 to the base of Q2 drives this transistor to cutoff.

The pulse applied to CR1 and CR4 has no effect on the state of Q1 since this transistor is already cut off.

As the load current in Q2 decreases, the potential on its collector approaches B-. This change in voltage level, coupled through resistor R10 and capacitor C2 to the base of transistor Q1, drives Q1 into the active region. As a result, Q1 begins to conduct, and the amplified current flowing through R1 causes the potential on the collector to fall to almost zero. Under these conditions, the diode base clamp CR3 combined with the divider network R11 and R21 maintains a positive potential at the base of Q2 to keep it cut off.

The binary, now in the "one" state, remains in this stable state until the next positive input pulse arrives. At that time, Q1 cuts off, Q2 conducts, and the binary resumes its original state.

The collector of each "normally off" transistor in the four binaries connects to a corresponding terminal of the DCU connector. Thus, the change in voltage level at each collector, as the binary changes state, is available as an output signal. The change in voltage level at the collector of each "normally on" transistor is used as the drive signal to the next binary. Therefore, each binary in the DCU reverses state for every two reversals of the preceding binary.

3.2 THE SCALE-OF-TEN CIRCUIT

The scale-of-ten circuit used in the Model 860 DCU is a four-place binary counter wired so that it resets to zero on every tenth input pulse. Operation is explained in detail in the following paragraphs.

3.2.1 Initial Conditions and Circuit Fundamentals

Under initial conditions, transistors Q2, Q4, Q6, and Q8 are saturated. Transistors Q1, Q3, Q5, and Q7 are cut off. These conditions define the "zero" state for each binary.

At this point, a review of transistor binary (flip-flop) circuit fundamentals may be helpful in understanding the circuit description in the following paragraphs.

Consider the first binary, transistors Q1 and Q2. Under initial conditions, Q1 is cut off and Q2 is saturated. Transistor Q1 is held at cutoff by divider network R18, R10, and clamp CR1. A positive input pulse applied at the junction of C10 and CR1, has no effect on Q1, since it is already cut off. While Q2 is saturated, its collector is near ground potential. Now, when the positive input pulse is applied through CR4 to the base of Q2, it drives Q2 into cutoff and the collector potential rises to approximately -12 volts. This negative transient, coupled to the base of Q1 through crossover network R10 and C2, drives Q1 into saturation.

Thus, on the first input pulse, the first binary "flips" and its transistors reverse their states. But the second binary is not affected since it takes a positive output pulse from the binary to cause the second binary to flip.

But on application of the second input pulse, circuit action produces a positive output signal to flip the second binary, as follows: the positive input pulse goes through C10 to the base of Q1 to cut it off. As Q1 cuts off, its collector potential rises to approximately -12 volts. This negative transient, coupled to the base of Q2 through crossover network R11 and C3, drives Q2 into saturation. When Q2 saturates, the collector potential goes from approximately -12 volts to approximately -0.2 volts. This positive-going pulse passes through C11 and CR6 to trigger the second binary. To summarize: a positive pulse applied to the first binary will cut off the saturated transistor, and regenerative action will drive the cut off transistor into saturation. The first binary will produce a driving pulse to the second binary only when the second transistor of the first binary goes from cutoff to saturation. Thus, the first binary will produce an output pulse only on every second input pulse, even though every input pulse will reverse the state of the binary. These principles apply to all of the binaries.

3.2.2 Sequence of Operation

PULSE NO.	ACTION
1	First binary flips. Q2 turns off. No output signal.
2	First binary flips. Q2 saturates. Output pulse flips second binary. Q4 turns off.
3	First binary flips. Q2 turns off. No output signal.
4	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q4 saturates. Output pulse from Q4 flips third binary and Q6 cuts off.
5	First binary flips. Q2 turns off. No output pulse from Q2.
6	First binary flips. Q2 saturates. Output signal from Q2 flips second binary. Q4 turns off. No output pulse from Q4.
7	First binary flips. No output signal from Q2.
8	First binary flips. Q2 saturates. Output pulse from Q2 flips second binary. Q4 saturates. Output pulse from Q4 flips third binary. Q6 saturates. Output pulse from Q6 flips fourth binary. Q8 cuts off. Negative 12 volts at collector of Q8 is applied to CR 9 and CR6 closing the gate.
9	First binary flips. No output from Q2.
10	First binary flips. Q2 saturates. Output signal from Q2 is blocked from second binary by closed gate CR9 and CR6. So it goes through C14 and CR9 to flip the fourth binary. Q8 saturates. The output pulse from Q8 goes to DCU output pin R.

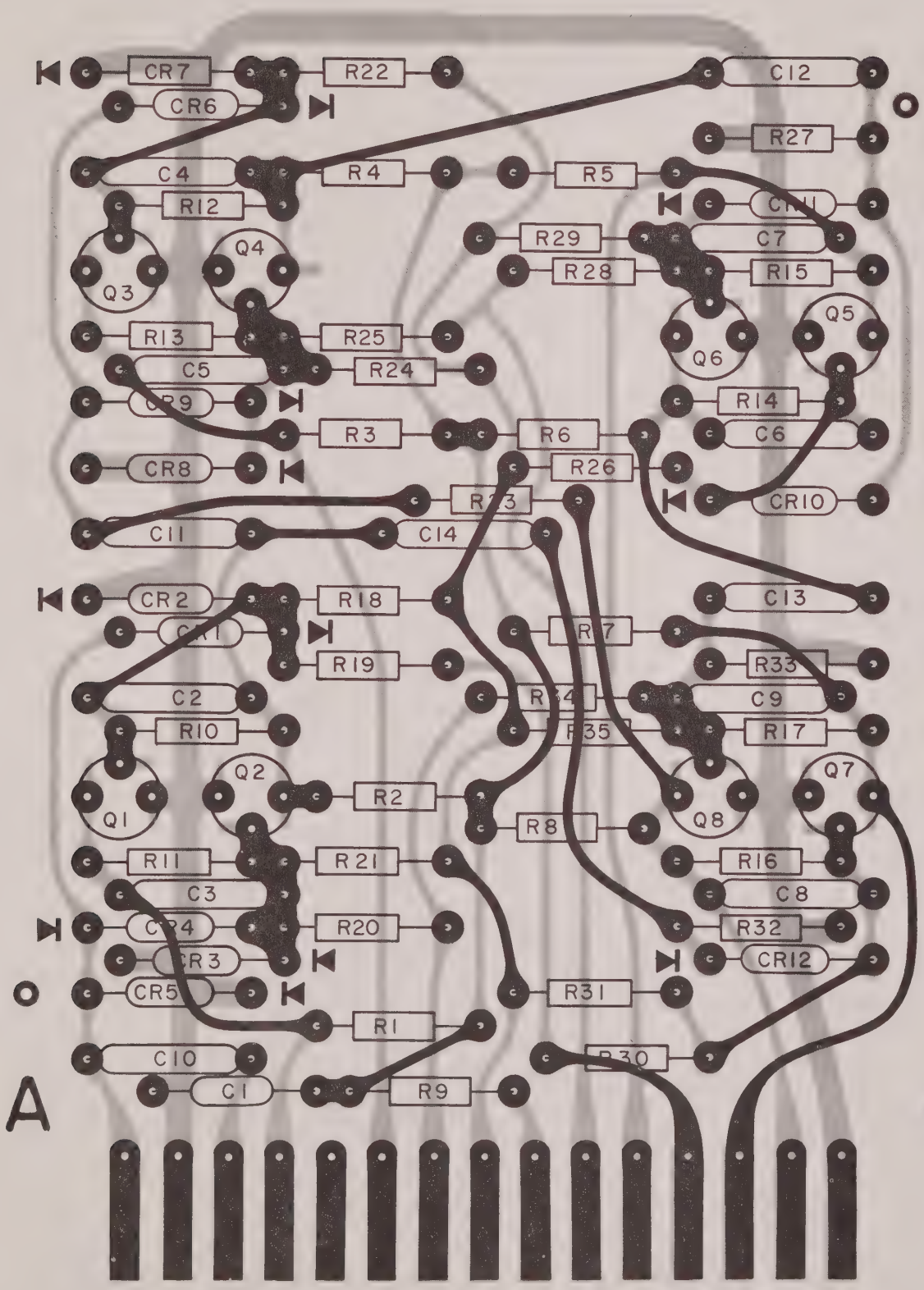
3.2.3 Summary

At the tenth input pulse, all four binaries are in the "zero" state and the DCU is ready for the next counting cycle. The positive output signal from transistor Q8, produced when the counter goes from nine to zero, can drive a Model 860 or 850 DCU. Thus, the counter will supply one input pulse to the next DCU for every ten counts registered.

The number of counts registered by the DCU is represented in binary-coded decimal form by the potentials on the readout line of the binaries.

Reset lines H and L connect through corresponding resistors to the base of the normally-on transistors (Q2, Q4, Q6, and Q8) in each binary. A negative voltage pulse applied to these reset lines will cause the normally-on transistors to conduct and trigger all binaries to the zero state.

Reset line N connects through a corresponding resistor to the base of the normally-off transistors Q1 and Q7. When a negative pulse is applied to line N, transistors Q1 and Q7 are turned on setting the 1st and 4th binaries to the "one" state. Applying a reset pulse to lines N and L simultaneously will set the DCU to the binary state of "1001", which is equivalent to 9.



MODEL 860 DCU COMPONENT LAYOUT

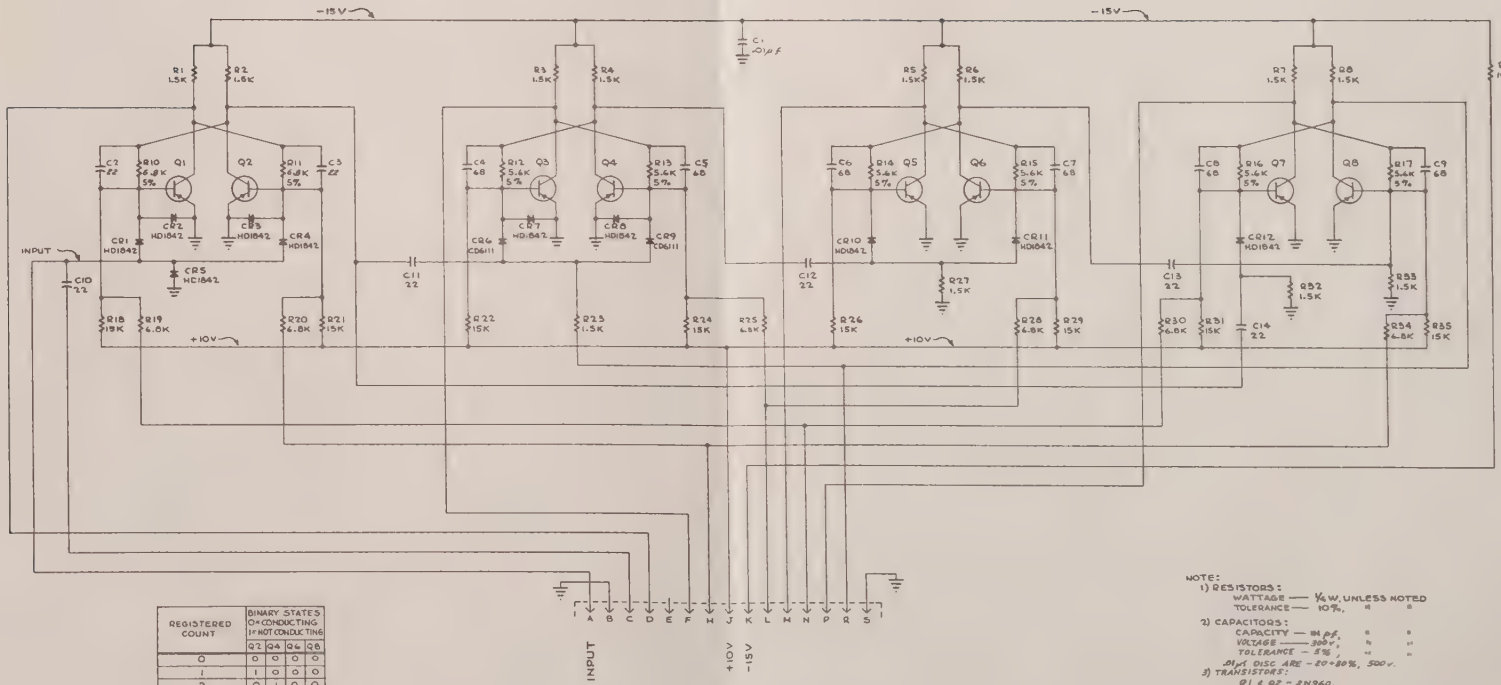
63-B-35

SECTION 4

PARTS LIST

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
C1	633-804717	Capacitor, F. Cerm., 0.01μf, 500V	1
C2	637-824008	Capacitor, F. Mica, 22pf, 300V, 5%	7
C3		Same as C2	
C4	637-824014	Capacitor, F. Mica, 68pf, 300V, 5%	6
C5 thru C9		Same as C4	
C10 thru C14		Same as C2	
CR1	755-824300	Diode, Germanium, type HD1842	10
CR2 thru CR5		Same as CR1	
CR6	755-815561	Diode, Silicon, 75PIV, 10 ma, 1V min. fwd.	2
CR7 & CR8		Same as CR1	
CR9		Same as CR6	
CR10 thru CR12		Same as CR1	
Q1	755-824880	Transistor, Germanium, PNP, 150mw	2
Q2		Same as Q1	
Q3	755-817587	Transistor, Germanium, PNP, 150mw	6
Q4 thru Q8		Same as Q3	
R1	601-823112	Resistor, F. Comp., 1.5K, 1/4W, 10%	12
R2 thru R8		Same as R1	

Detail No.	Beckman Stock No.	Description	Qty./ Ass'y
R9	601-823917	Resistor, F. Comp., 10Ω, 1/4W, 10%	1
R10	601-822299	Resistor, F. Comp., 6.8K, 1/4W, 5%	2
R11		Same as R10	
R12	601-822397	Resistor, F. Comp., 5.6K, 1/4W, 5%	6
R13 thru R17		Same as R12	
R18	601-823107	Resistor, F. Comp., 15K, 1/4W, 10%	8
R19	601-823945	Resistor, F. Comp., 6.8K, 1/4W, 10%	6
R20		Same as R19	
R21 & R22		Same as R18	
R23		Same as R1	
R24		Same as R18	
R25		Same as R19	
R26		Same as R18	
R27		Same as R1	
R28		Same as R19	
R29		Same as R18	
R30		Same as R19	
R31		Same as R18	
R32 & R33		Same as R1	
R34		Same as R19	
R35		Same as R18	
	864-412958	Pad, Transistor	8



REGISTERED COUNT	BINARY STATES 0=CONDUCTING 1=NOT CONDUCTING			
	Q2	Q4	Q6	Q8
0	0	0	0	0
1	1	0	0	0
2	0	1	0	0
3	1	1	0	0
4	0	0	1	0
5	1	0	1	0
6	0	1	1	0
7	1	1	1	0
8	0	0	0	1
9	1	0	0	1

NOTE:
1) RESISTORS:
WATTAGE — 1/4 W, UNLESS NOTED
TOLERANCE — 10%,
2) CAPACITORS:
CAPACITY — IN pf,
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TOLERANCE — 5%,
.01μf DISC ARE -20+80%, 500 v.
3) TRANSISTORS:
Q1 & Q2 - 2N960.
Q3 THRU Q8 - 2N868.

Model 860 DCU
D411932-Rev. B
January 1963

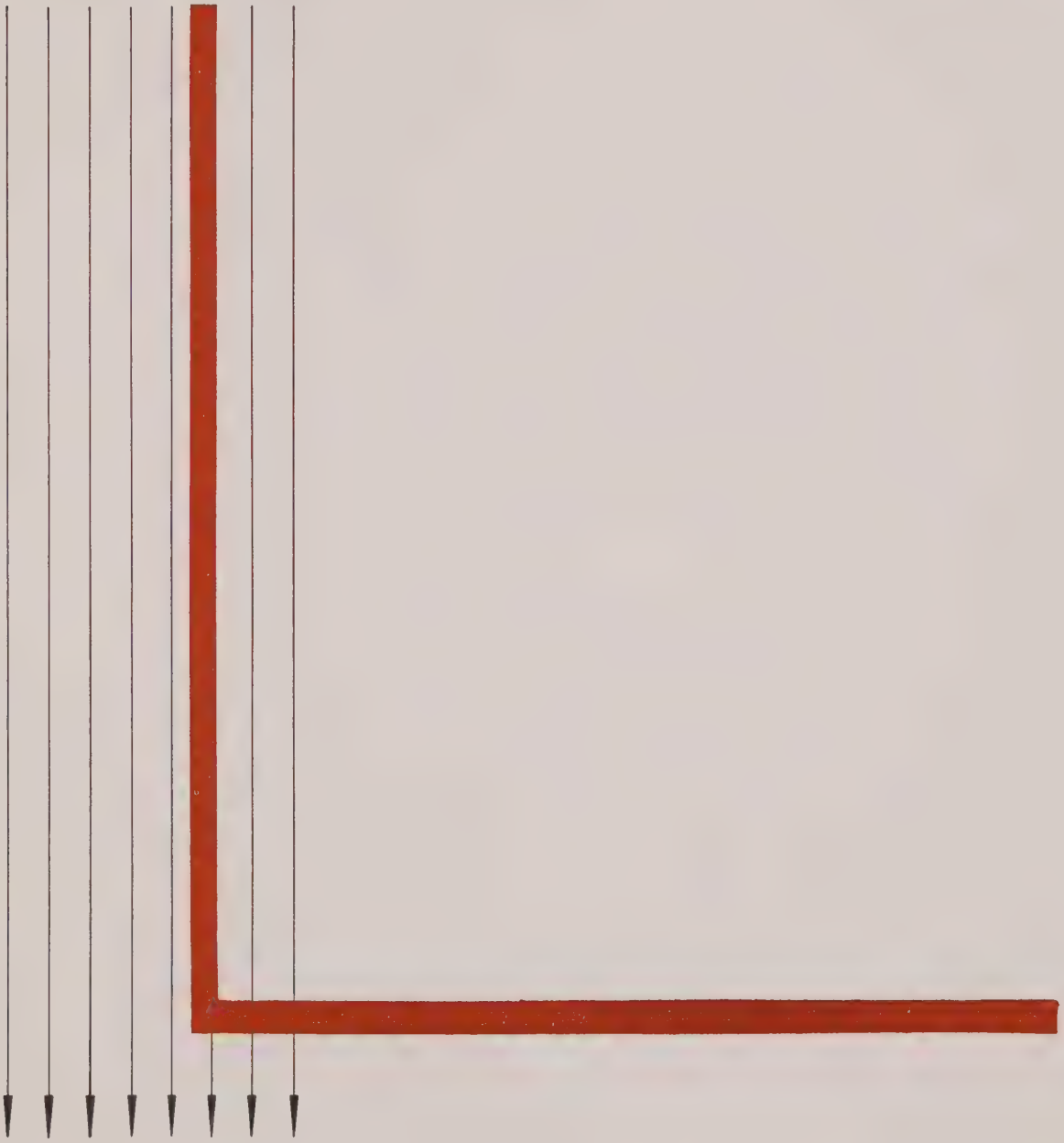
Beckman®

- Parts List -

Detail	Beckman	Qty./

INSTRUCTION MANUAL

DATA STORAGE UNIT



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BERKELEY DIVISION
BECKMAN INSTRUMENTS, INC.

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DIAGRAMS

Data Storage Unit Decoder Block	62-D-88
Data Storage Unit Schematic	D410532 - Rev. D
Data Storage Unit Component Layout	63-C-8

SECTION 1
INTRODUCTION

1.1 GENERAL

The Data Storage Unit (DSU) stores binary coded information received from a decimal counting unit (DCU) such as Beckman Model 850, 860, or 870, and displays this information on a separate electroluminescent readout. Upon command, the DSU converts binary information into a decimal equivalent. The DSU comprises a plug-in printed circuit board using all solid-state components.

1.2 SPECIFICATIONS

Table 1-1. Main Characteristics

COUNT DISPLAY	In-line digit on Sylvania Series NU-50 Electroluminescent panel (separate from DSU)
DISPLAY CONTROL OUTPUTS	Segment off: 50 volts p-p (typical) Segment on: 900 volts p-p (typical)
INPUT REQUIREMENTS (from DCU)	Binary "1" -6 volts Binary "0" -0.3 volts
CLEAR PULSE	-10 volts, 5 μs duration
SET PULSE	-10 volts, 5 μs duration
POWER REQUIREMENTS	B+ +105 volts at 10 ma +10 volts at 2 ma B- -15 volts at 23 ma Display 900 volts p-p, 500 cps
DIMENSIONS	6.56 inches by 4.09 inches
WEIGHT	5.3 oz.
MOUNTING	Two 15-pin P. C. Board Connectors

SECTION 2
OPERATION

2.1 INSTALLING THE DSU

The DSU plugs into two 15-pin printed card connectors.

2.2 INPUT REQUIREMENTS

Table 1-1 summarizes the input requirements of the DSU.

2.3 OUTPUT CHARACTERISTICS

2.3.1 Display Control Output

For each decimal digit (0 through 9) registered, a decoder in the DSU generates a combination of on/off voltages to control segments of a Sylvania series NU-50 electroluminescent display. Typical voltages are 50 volts peak-to-peak to extinguish a segment, and 900 volts peak-to-peak to light a segment.

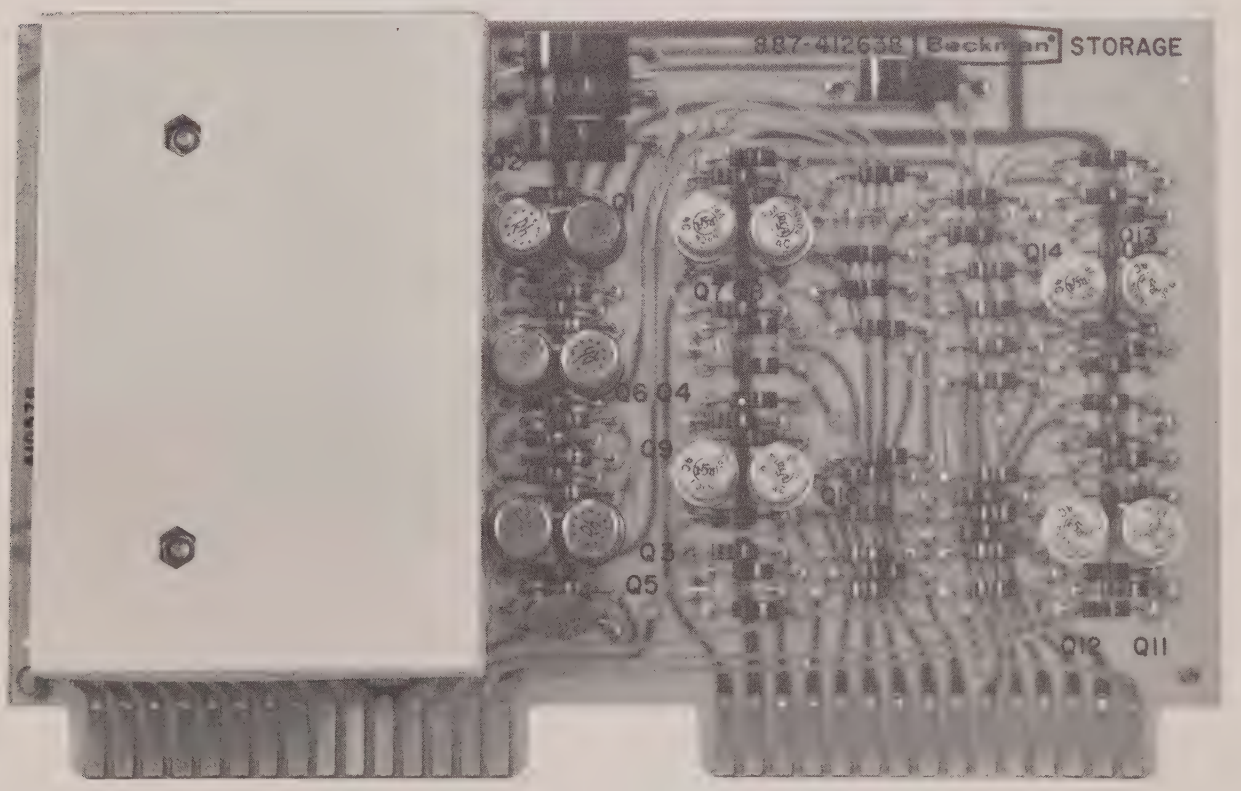


FIG. 2-1. Data Storage Unit Plug-in Printed Circuit Board

SECTION 3
CIRCUITS

3.1 BASIC CIRCUITS

As shown in Figure 3-1, the DSU comprises a storage and decoding circuit with a separate digital display. Section 3.2 describes the storage circuit, a set of four binary (flip-flop) stages. Section 3.3 explains how the decoding logic converts the stable states of the binaries into seven lines of display control information.

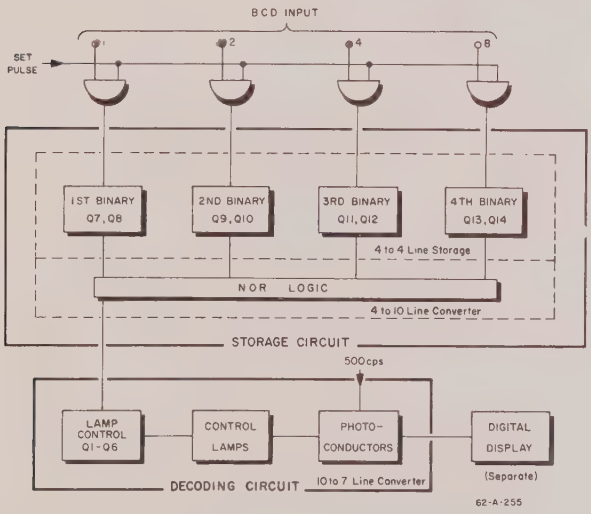


FIG. 3-1. Flow Diagram of Data Storage Unit

3.2 THE STORAGE CIRCUIT

Four binaries make up the storage circuit. Each binary comprises a pair of p-n-p transistors with the collector of each transistor directly coupled to the base of the other. Being symmetrical, the circuit can exist in either of two stable states: one transistor is cut off (OFF), and the other is conducting (ON).

In a p-n-p transistor, the input impedance is low (in the order of a thousand ohms) when the base potential is negative. This low input impedance permits a base current to flow and the transistor conducts. Conversely, a positive base potential results in a high input impedance (several hundred thousand ohms); therefore, no base current flows and the transistor is cut OFF.

Figure 3-2 shows a typical binary in the "0", or clear, state (Q7 ON, Q8 OFF) and explains how the circuit stabilizes itself in that state.

With a negative voltage applied to the input terminal and a negative set pulse to R76, the binary changes states by a process described in Figure 3-3. During the change, the collector voltage of one transistor drops sharply while the other rises. These collector voltage swings drive transistors Q1-Q6 to provide the logic needed in converting the stable states of the four binaries into seven lines of display control information.

Driven by the storage binaries, transistors Q1-Q6 control the neon lamps. Depending on the ON-OFF combination of transistors Q1-Q6, neon lamps DS1 - DS15 light in appropriate combinations to provide the logic needed to control the electroluminescent segments.

Two conditions must exist before a neon lamp will light: enough potential to "fire" the lamp, and a complete current path. These two conditions are met by the ON-OFF combination of transistors Q1-Q6. Transistors Q3-Q6 act as switches to complete the current path for the lamps, while Q1 and Q2 set the potential for firing the correct lamps. Together, Q1-Q6 form the neon lamp control circuit.

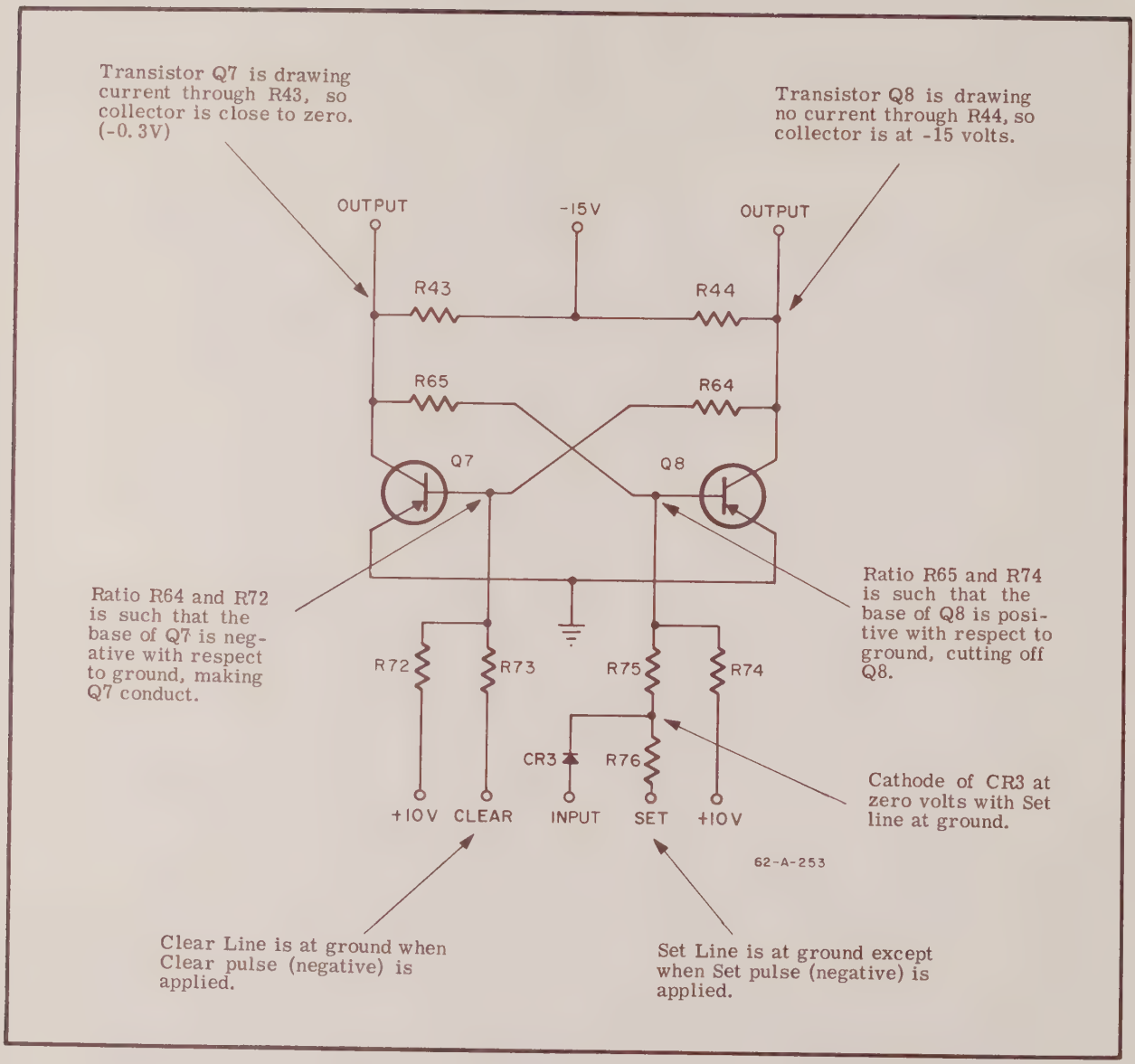

Transistor Q7 is drawing current through R43, so collector is close to zero. (-0.3V)
Transistor Q8 is drawing no current through R44, so collector is at -15 volts.
OUTPUT
-15V
OUTPUT
R43
R44
R65
R64
Q7
Q8
Ratio R64 and R72 is such that the base of Q7 is negative with respect to ground, making Q7 conduct.
Ratio R65 and R74 is such that the base of Q8 is positive with respect to ground, cutting off Q8.
R72
R73
R75
R74
CR3
R76
Cathode of CR3 at zero volts with Set line at ground.
+10V
CLEAR
INPUT
SET
+10V
62-A-253
Clear Line is at ground when Clear pulse (negative) is applied.
Set Line is at ground except when Set pulse (negative) is applied.

FIG. 3-2. A Typical Storage Binary in the "0" State

Figure 3-4 shows in simplified form the logic used to control the lamps. As shown, the storage binaries drive the lamp control circuits. When the storage binaries set, the lamp control transistors follow by either turning ON or OFF (Q1 normally ON, Q2-Q6 normally OFF in clear state).

The neon control circuits use n-p-n transistors instead of p-n-p transistors as in the storage binaries. Unlike the p-n-p transistor, the n-p-n transistor requires a positive voltage to turn it ON, and a negative voltage to turn if OFF. For example, assume these conditions exist using Figure 3-4 as a guide: Q2, Q3 and Q5 ON, Q1

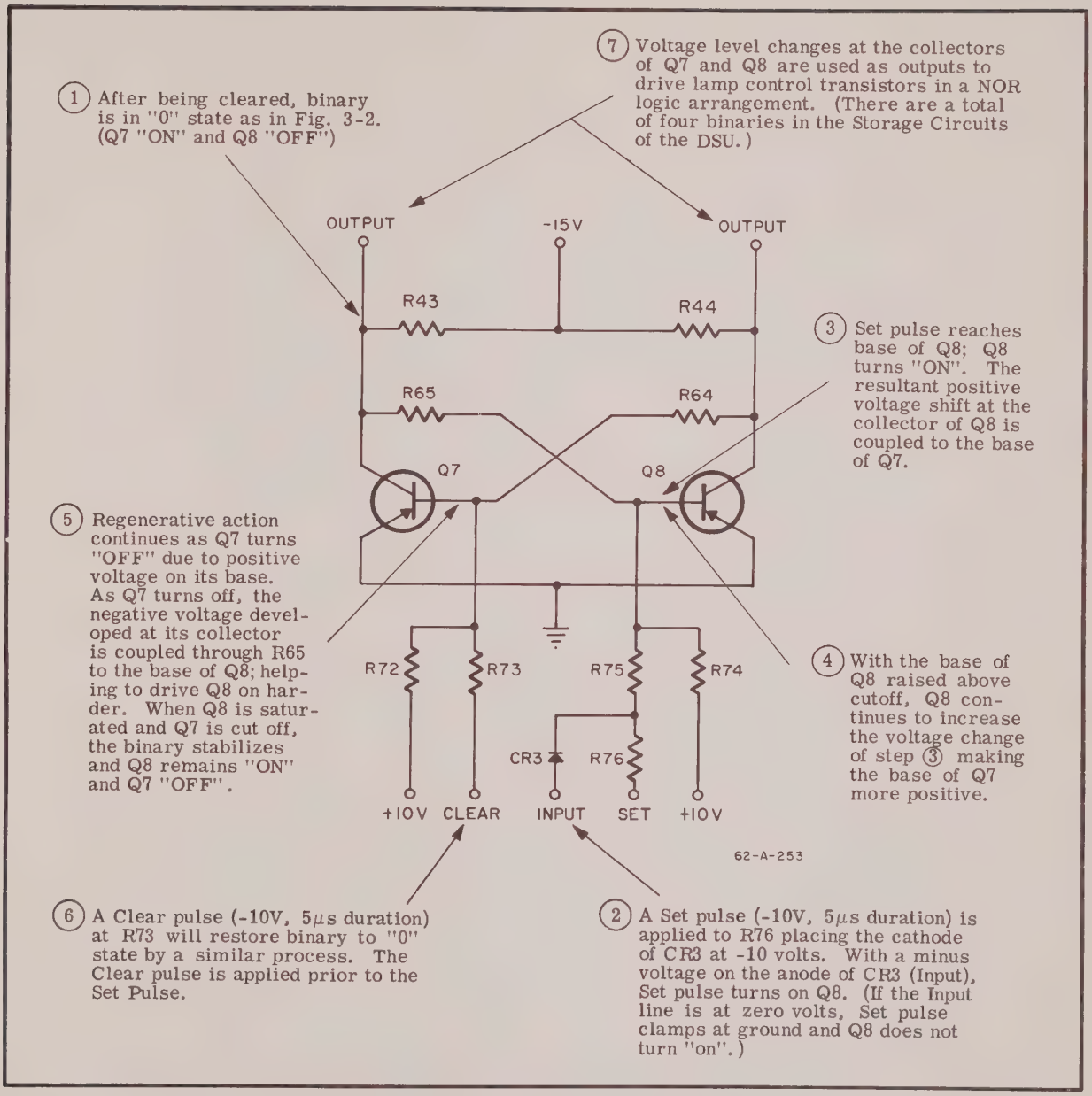

7 Voltage level changes at the collectors of Q7 and Q8 are used as outputs to drive lamp control transistors in a NOR logic arrangement. (There are a total of four binaries in the Storage Circuits of the DSU.)
1 After being cleared, binary is in "0" state as in Fig. 3-2. (Q7 "ON" and Q8 "OFF")
OUTPUT
-15V
OUTPUT
R43
R44
R65
R64
Q7
Q8
3 Set pulse reaches base of Q8; Q8 turns "ON". The resultant positive voltage shift at the collector of Q8 is coupled to the base of Q7.
5 Regenerative action continues as Q7 turns "OFF" due to positive voltage on its base. As Q7 turns off, the negative voltage developed at its collector is coupled through R65 to the base of Q8; helping to drive Q8 on harder. When Q8 is saturated and Q7 is cut off, the binary stabilizes and Q8 remains "ON" and Q7 "OFF".
R72
R73
R75
R74
CR3
R76
4 With the base of Q8 raised above cutoff, Q8 continues to increase the voltage change of step 3 making the base of Q7 more positive.
+10V
CLEAR
INPUT
SET
+10V
62-A-253
6 A Clear pulse (-10V, 5μs duration) at R73 will restore binary to "0" state by a similar process. The Clear pulse is applied prior to the Set Pulse.
2 A Set pulse (-10V, 5μs duration) is applied to R76 placing the cathode of CR3 at -10 volts. With a minus voltage on the anode of CR3 (Input), Set pulse turns on Q8. (If the Input line is at zero volts, Set pulse clamps at ground and Q8 does not turn "on".)

FIG. 3-3. Stages in the Transition of a Binary From the "0" State to the "1" State

OFF. With Q2 on, a voltage drop appears across R10 reducing the potential on DS1 and DS2 below the ignition point, even though Q3 is ON establishing a current path. But DS4 will fire since one side is tied to +110 volts and Q3 provides a current path.

Since Q1 is off, no voltage drop appears across R9. Lamps DS8 and DS9 can fire since Q5 is ON completing the current path. Note also that the collector of Q10 and the base of Q5 are tied together through R51 to form the NOR logic. If a positive voltage appears across R50 and turns

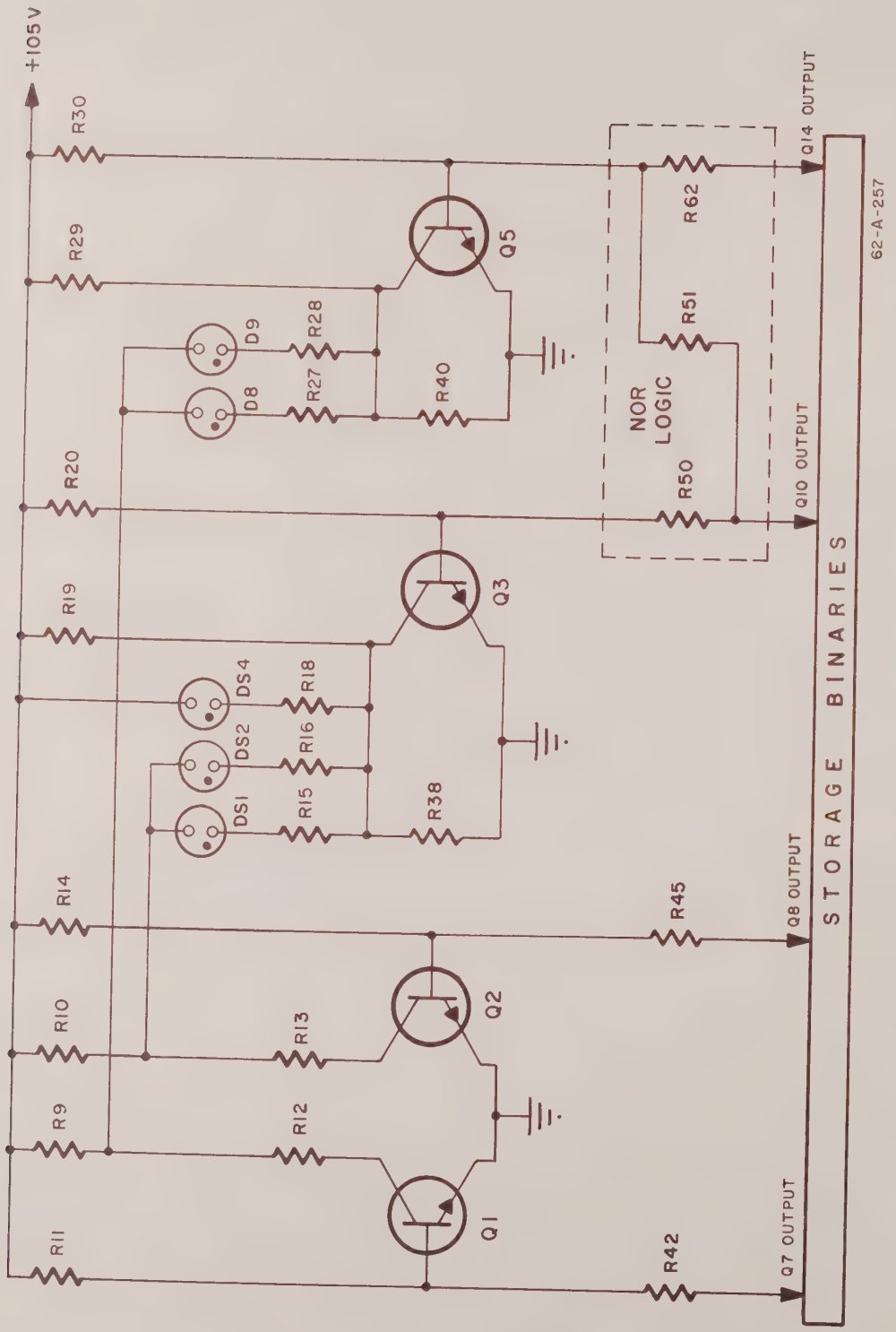


FIG. 3-4. Partial Schematic Indicating Lamp Control Logic

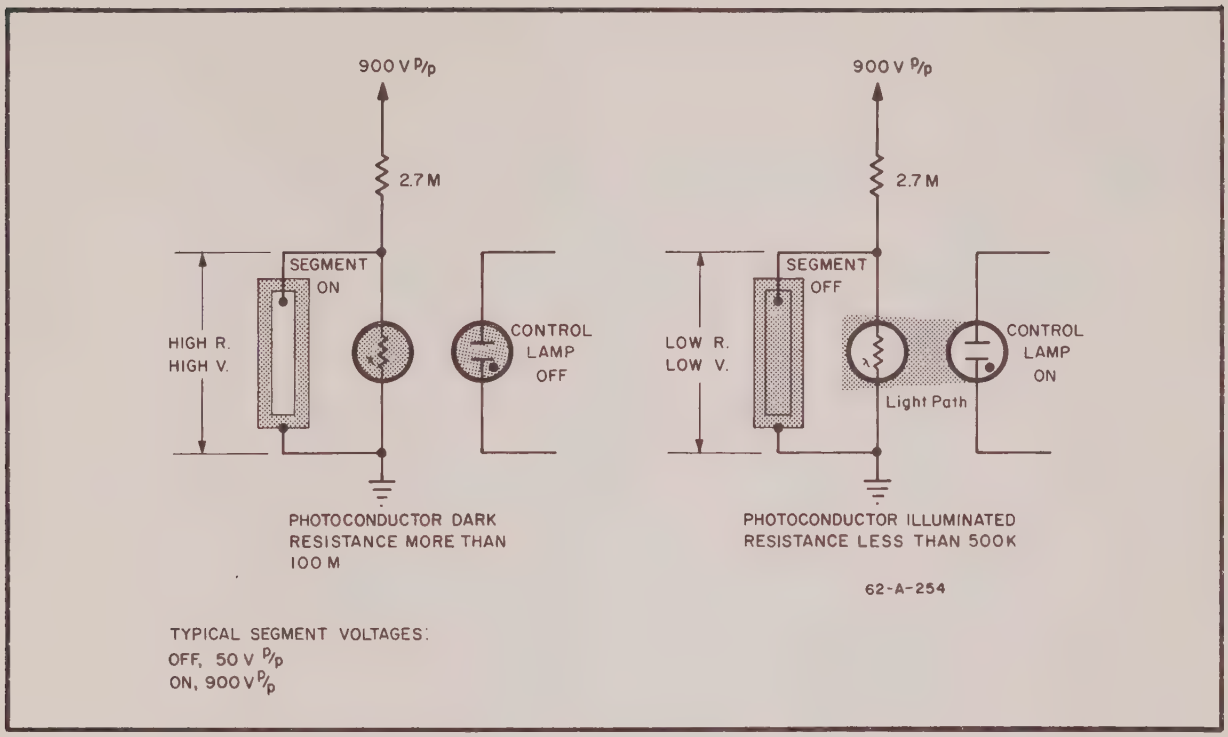


FIG. 3-5. The Basic Photoconductor Switching Circuit in Its Two States: Control Lamp "OFF", and Control Lamp "ON". "Low" and "High" are relative, not absolute, terms.

on Q3, but a negative voltage appears across R62 simultaneously, the negative voltage would override the positive voltage and turn Q3 and Q5 off. The schematic diagram shows in more detail the NOR logic that exists between the storage binaries and the lamp control transistors.

As described in Section 3.2, the storage circuit registers the decimal digits "0" through "9" as different voltage combinations on the collectors of the binaries. Using neon lamps, transistors, and photoconductors, the decoder converts the combinations into ON/OFF voltages controlling seven display segments on an electroluminescent panel.

Figure 3-5 shows the basic decoding circuit, which uses a photoconductor as the variable arm of a voltage divider. When the photoconductor is in total darkness, its internal resistance is more than 100 megohms. In the light of the neon "control" lamp, however, the resistance drops to less than 500K ohms. Thus, an electroluminescent segment connected across the photoconductor is switched on and off by the lamp.

The Decoder Block Schematic Diagram shows the complete decoder with its 16 control lamps. Lamp DS15 lights at all odd counts and turns off the lower segment (E) of the display. Lamp DS16 controls the decimal point (if one is used). Combinations of the other 14 lamps represent one registered count (0 through 9) and light at that count only.

Segment control is required for all digits except number 8. The lamps are enclosed with the photoconductors in a light-tight optical maze.

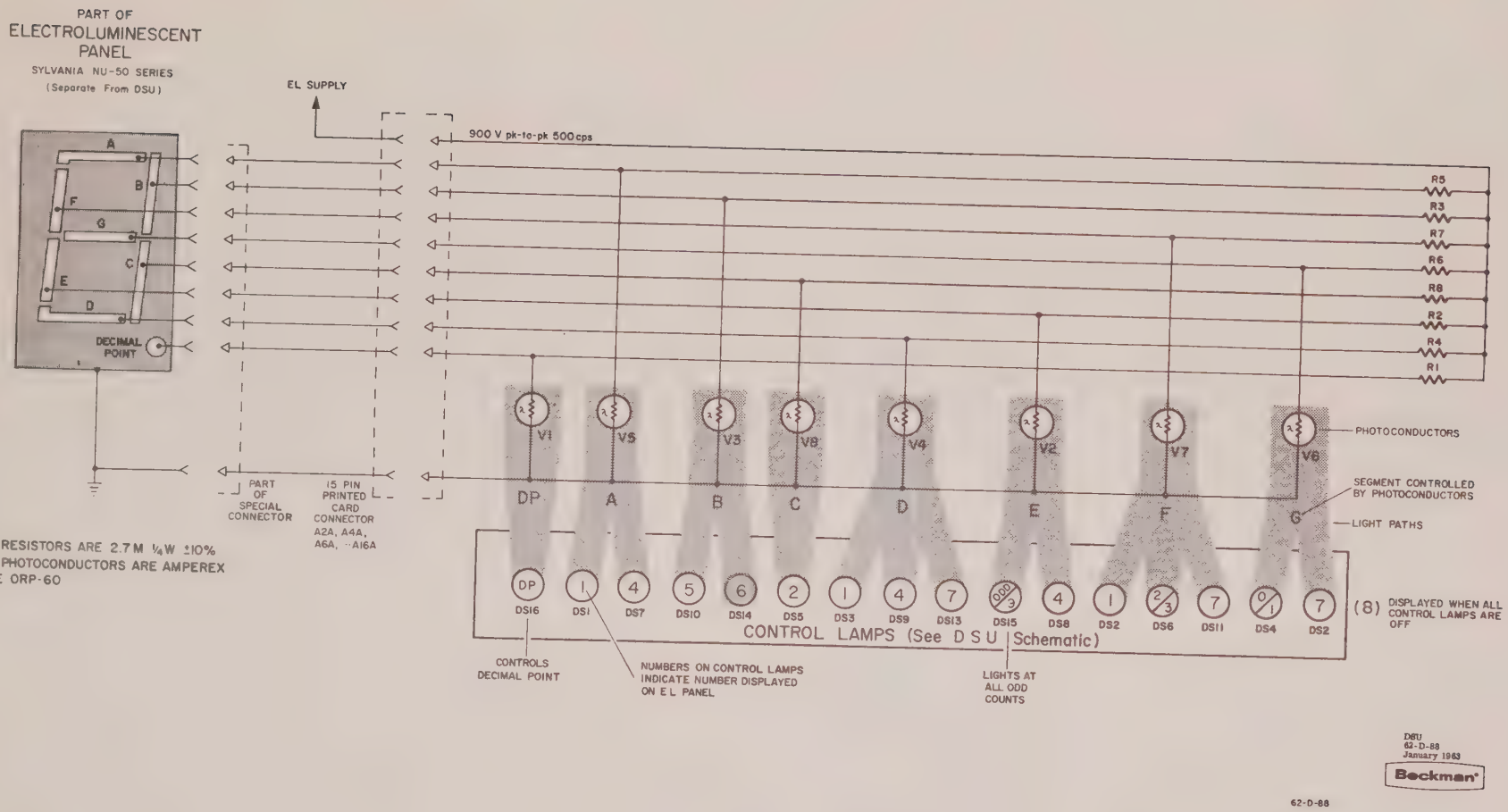
SECTION 4
PARTS LIST

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
C1	633-804717	Capacitor, F. Cerm., 0.01 μf, 500V	Sprague 29C9B5	1
CR1 thru CR6	755-402107	Diode, Special, 1N95	Beckman/Berkeley	6
DS1 thru DS16	825-414955	Lamp, Neon	B/B	16
Q1 thru Q6	755-410066	Transistor, Silicon, NPN	B/B	6
Q7 thru Q14	755-800398	Transistor, Germanium, PNP, 150 mw, Max.	Sylvania 2N404	8
R1 thru R8	601-824112	Resistor, F. Comp, 2.7M, 1/4W, 10%	Allen Bradley CB2751	8
R9 & R10	601-023764	Resistor, F. Comp, 3.9K, 1W, 5%	Allen Bradley	2
R11	601-823956	Resistor, F. Comp, 150K, 1/4W, 10%	Allen Bradley CB1541	2
R12 & R13	601-800065	Resistor, F. Comp, 3.3K, 1W, 5%	Allen Bradley	2
R14		Same as R11		
R15 thru R17	601-822798	Resistor, F. Comp, 68K, 1/4W, 5%	Allen Bradley	6
R18	601-822337	Resistor, F. Comp, 91K, 1/4W, 5%	Allen Bradley CB9135	3
R19	601-823959	Resistor, F. Comp, 330K, 1/4W, 10%	Allen Bradley CB3341	4
R20	601-823962	Resistor, F. Comp, 560K, 1/4W, 10%	Allen Bradley CB5641	4
R21	601-822543	Resistor, F. Comp, 82K, 1/4W, 5%	Allen Bradley CB8235	2
R22		Same as R18		
R23		Same as R19		
R24		Same as R20		
R25 thru R27		Same as R15		
R28	601-822543	Resistor, F. Comp, 82K, 1/4W, 5%	Allen Bradley	1
R29		Same as R19		
R30		Same as R20		
R31 thru R33		Same as R15		
R34		Same as R21		
R35		Same as R19		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
R36		Same as R15		
R37		Same as R18		
R38 thru R41	601-823963	Resistor, F. Comp, 680K, 1/4W, 10%	Allen Bradley CB6841	4
R42	601-823108	Resistor, F. Comp, 10K, 1/4W, 10%	Allen Bradley CB1031	6
R43 & R44	601-823942	Resistor, F. Comp, 3.3K, 1/4W, 10%	Allen Bradley CB3321	8
R45		Same as R42		
R46 & R47	601-823950	Resistor, F. Comp, 39K, 1/4W, 10%	Allen Bradley CB3931	12
R48 & R49		Same as R43		
R50 thru R53		Same as R46		
R54 & R55		Same as R43		
R56 & R57		Same as R46		
R58 & R59		Same as R43		
R60 thru R63		Same as R46		
R64 thru R71	601-822333	Resistor, F. Comp, 12K, 1/4W, 5%	Allen Bradley CB1235	8
R72	601-823109	Resistor, F. Comp, 33K, 1/4W, 10%	Allen Bradley CB3331	8
R73		Same as R42		
R74		Same as R72		
R75	601-815239	Resistor, F. Comp, 4.7K, 1/4W, 10%	Allen Bradley CB4721	4
R76	601-823944	Resistor, F. Comp, 5.6K, 1/4W, 10%	Allen Bradley CB5621	4
R77		Same as R42		
R78 & R79		Same as R72		
R80		Same as R75		
R81		Same as R76		
R82		Same as R42		
R83 & R84		Same as R72		
R85		Same as R75		
R86		Same as R76		
R87		Same as R42		
R88 & R89		Same as R72		

Detail No.	Beckman Stock No.	Description	Typical Manufacturer & No.	Qty./ Ass'y
R90		Same as R75		
R91		Same as R76		
R92		Same as R20		
V1 thru V8	753-416278	Photo-Resistor, END-View, Special	B/B	8
	864-412958	Pad, Connector, Transistor	B/B	14
	824-412922	Lamp Block, Base	B/B	1
	824-414475	Lamp Block, Cover	B/B	1

DSU DECODER
BLOCK DIAGRAM



NOTES:
(1) ALL RESISTORS ARE 2.7 M ¼W ±10%
(2) ALL PHOTOCONDUCTORS ARE AMPEREX TYPE ORP-60

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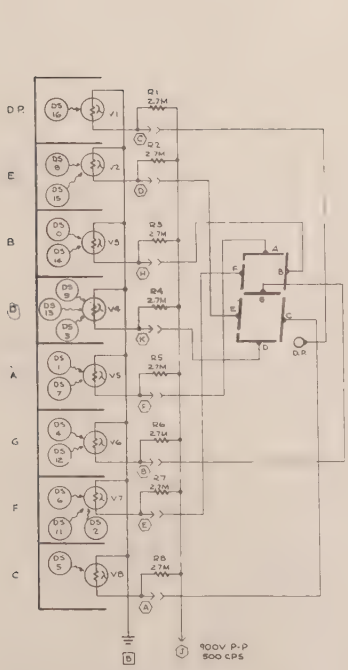
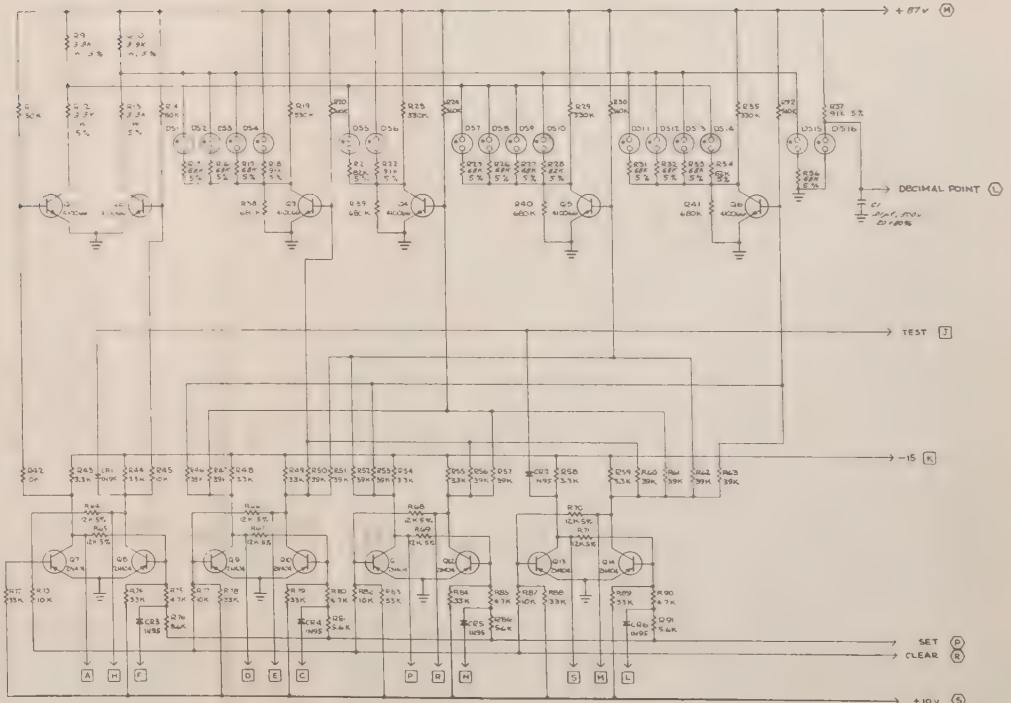
DSU SCHEMATIC DIAGRAM



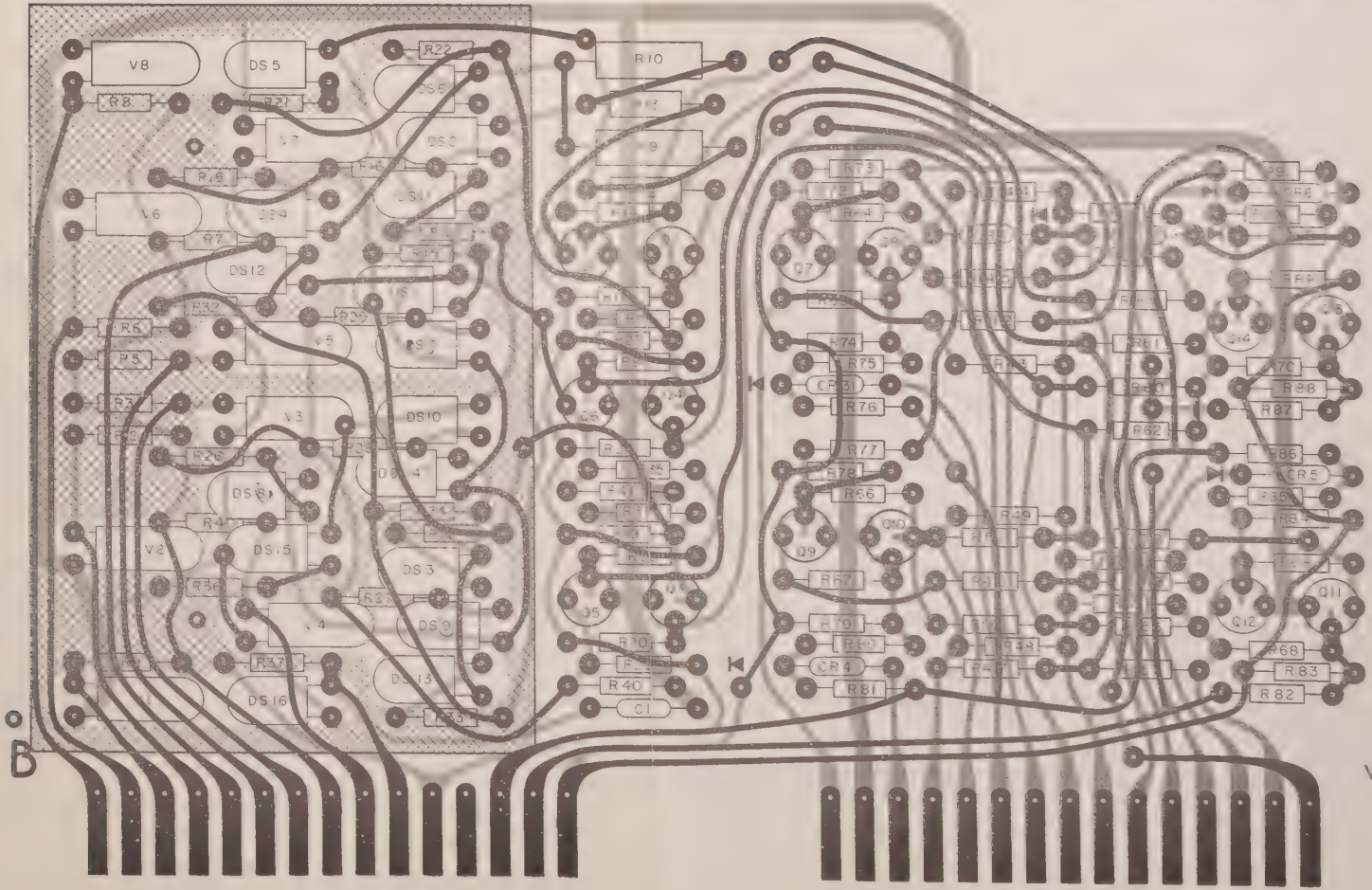
NOTE:
1) ALL RESISTORS:
WATTAGE — ½W UNLESS NOTED
TOLERANCE — 10% UNLESS NOTED
2) ○— INDICATES PINS OF P1 (FRONT CONNECTOR)
3) □— " " " P2 (REAR CONNECTOR)
4) ALL PHOTORESISTORS (V1 THRU V8) ARE TO BECKMAN SPEC., DWG. 753-406578.
5) ALL NEON LAMPS (DS1 THRU DS16) ARE TO BECKMAN SPEC., DWG. 865-914331.



Data Storage Unit
0410533 Rev. D
October 1963

Beckman

DATA STORAGE UNIT COMPONENT LAYOUT



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